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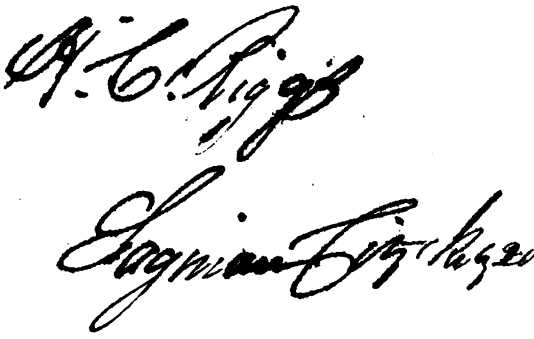

UNIV. OF MICH.

THE

ELEMENTS

OF

ASTRONOMY.

THE

ELEMENTS

OF

ASTRONOMY;

WITH METHODS FOR DETERMINING THE

LONGITUDES, ASPECTS, &c. OF THE PLANETS

FOR ANY FUTURE TIME;

AND

AN EXTENSIVE SET OF GEOGRAPHICAL AND ASTRONOMICAL PROBLEMS ON THE

GLOBES.

DESIGNED FOR THE

USE OF SCHOOLS AND JUNIOR STUDENTS.

BY S. TREEBY.

TEACHER OF THE MATHEMATICS, CLASSICS, &c. &c.

Second Edition.

REVISED AND CORRECTED

BY M. NASH,

TEACHER OF MATHEMATICS, NEW-YORK.

NEW-YORK:

PUBLISHED BY SAMUEL WOOD & SONS,

NO. 261, PEARL-STREET.

1826.

SOUTHERN DISTRICT OF NEW-YORK, ss.

BE IT REMEMBERED, That on the twenty-eighth day of March, in the forty-seventh year of the Independence of the United States of America, Samuel Wood & Sons, of the said District, have deposited in this office, the title of a book, the right whereof they claim as proprietors, in the words following, to wit:

"The Elements of Astronomy; with methods for determining the longitudes, aspects, &c. of the planets for any future time; and an extensive set of Geographical and Astronomical Problems on the globes. Designed for the use of schools and junior students. By S. Treeby, teacher of Mathematics, Classics, &c. &c. Revised and corrected by M. Nash, teacher of Mathematics, New-York"

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Before the appearance of Treeby's Elements of Astronomy, although many valuable treatises had been written on the same subject, a great part of them were better adapted to the course of instruction embraced in colleges, than the more limited range of studies pursued in common schools. A book was still wanted, which should explain in a more familiar manner, the definitions, general principles and facts of Astronomy, illustrated by a suitable number of problems, to be performed by the globes, so as to make the acquisition of this science, as part of a polite education, as easy as that of Geography. This work, it was thought, possessed in an eminent degree, all those valuable properties.

The present edition has undergone a thorough revision, and a number of errors that were overlooked in the first edition, have been corrected.

In page 213, some observations are made on the Planetary Problems, and a few instructions given on the practical use of the globes.

M. NASH.

New-York, Oct. 2, 1826.

PREFACE.

Of all the subjects that engage the lucubrations of the sage, the speculations of the philosopher, or which enrich the understandings of mankind, Astronomy is, without competition, the most sublime. It is nothing less than the contemplation of the operations of omnipotent power, directed by infinite wisdom, which are circulated through boundless space, for the happiness of an incalculable number of created beings, whether they live with us upon the earth, are inhabitants of our satellite the Moon, or residents of the purer regions of Mercury, or the denser climates of Saturn; all are the offspring of one benign parent, and partake alike of his fatherly munificence.

The science of Astronomy is not speculative, but its truths are demonstrable as its study is sublime. Proceeding upon principles, which are incontestable, the Astronomer informs us of the velocity of any celestial body, however swift its motion; its magnitude, however extensive; its distance, however remote; he traces its orbit, whatever its orbicular curve; he beautifully harmonises the varieties of our seasons; illustrates the causes of our unequal days and nights; informs us how great the altitudes of the variegated clouds are, which so conspicuously emanate from the earth; shows us the swiftness with which they skim through our

atmosphere; and, as he is acquainted with the various motions of the celestial bodies, so he predicts their configurations for any future period, however distant, with a certainty, which those unacquainted with astronomical investigations behold with astonishment; but its *utility* is as apparent as its contemplation is majestic; by its knowledge commerce is promoted, and the intercourse between distant nations facilitated, so that the exuberant fertility of one country is exported to supply the barrenness of an other, and with the assistance of its knowledge, the mariner guides his vessel across the trackless ocean with as much certainty as he displays in his pedestrious journey from one well known place to another. A farther proof of its utility, is its universal cultivation, *combined* with the characters of its students. It is not only in England or France that Astronomy is cultivated, but in Germany, in Denmark, nay, in every civilized nation of the world, observatories are erected, which oracularly prove, that this is considered the preeminent of the sciences; and, as genius and talent are elicited by public patronage, so the greatest and most learned men, in all ages, have been dignified by the appellation of Astronomers. From a consideration of the sublimity and utility of the sciences, we can not wonder that treatises thereon are numerous, or that efforts have been made to reduce its truths to the level of the juvenile capacity; and yet, *probably* owing to the profundity of erudition enjoyed by the respective writers, there does not exist a single isolated volume calculated for the general purposes of scholastic education; and the writer of this is persuaded, that this sublime science has been secluded from many seminaries, teachers not having been able to procure an ele-

mentary volume suited to the ages and understandings of their pupils. The design of the author of the present work is to supply this deficiency; and, as plainness, united with a desire to be understood, rather than to be admired, have been the objects he has had constantly in view; as he has not endeavoured to display his learning by copying or inventing a multiplicity of analytical expressions or unnecessary technical phrases; as he intends to use the work in his own school; and, as he has had considerable experience in education, he imagines he has succeeded. It is unnecessary minutely to describe the present work, or pursue it through its various ramifications; its merits or defects will be easily observed from a perusal of its contents; but it must be obvious from inspection, that it not only contains "multum in parvo," but "multum ad parvum."

The planetary problems are a novelty in an astronomical work, and have not hitherto been published, that the author has ever seen: they will furnish the student who has made some proficiency in arithmetic, with amusement as well as information.

The problems to be performed by the globes, will be found particularly adapted to the study of that pleasing, interesting, and instructive department of education; among them is the manner of solution of the problem for determining the time of *shortest* twilight, being in no other work extant: the solution of this problem has caused mathematicians much trouble, and has been the cause of acrimonious altercations among them.

The Vocabulary of Astronomical Terms, &c. &c. at the end of the work, is an agreeable and useful accompaniment; it will be particularly advantageous to the

student, by being committed to memory, as his age or capacity may determine. The book of questions on this treatise, is essentially necessary to the student, who wishes to have a complete knowledge of the facts interspersed through the work, as they are discriminately arranged, and bear immediately on the facts, they are admirably calculated to imprint the subject on his mind; they are divided into two sections; the first bearing upon the numbered articles, and the second on the observations.

The present work, with the book of questions, are not only well adapted to seminaries in which young gentlemen are educated, but in seminaries of female education they will be found particularly suited; and young ladies may, from them, be as easily initiated into the rudiments of Astronomy, as they are taught English grammar, geography, or any branch of female education.

In conclusion, the author will elucidate the method he adopts in exercising his pupils, to ascertain and facilitate their progress in any particular branch of literature, which experience has evinced to be a successful plan, and according to which, "The Elements of Astronomy" may be used in any seminary with success. He furnishes those of them who are able to read tolerably well, with the treatise, and denominates them "The Astronomical Class:" once in a day he calls the said class to read; when they have read three or four pages, without the observations, which they read after having gone through the work once, they turn to the question book, and ask themselves three or four rounds of questions therefrom; No. 2 first asks No. 1; No. 3 then asks No. 2, and so on, taking notice that the last

round of questions be from the Vocabulary; frequently the writer interrogates them more satisfactorily to prove their proficiency. Two or three times a week he gives them an astronomical exercise, which consists of about six questions delivered out prior to their leaving school on an evening, which they are required to answer written at length upon their slates by the ensuing morning: this, as well as employing them at home, teaches them to spell correctly, write fluently, and learn Astronomy simultaneously; and, upon this plan, English grammar, geography, history, or almost any branch of literature may be successfully taught. After having said thus much, he has only to notice, that he intends to accommodate those teachers whose pupils are numerous, with a key to the question-book, which will also contain solutions to the questions on the planetary problems in this work as soon as oportunity will allow; in the mean time he casts his work upon the good sense and candour of an enlightened public; and should it be so fortunate as to be considered by them adequate to answer its design, he shall consider his labour not unprofitably bestowed.

Plymouth, January 5, 1821.

ELEMENTS

OF

ASTRONOMY.

&c. &c.

PART I.

ASTRONOMICAL DEFINITIONS.

1. A PLANET is an opaque body, which revolves round, derives light from, and shines by, the help of another body.

Planets are divided into Primary and Secondary.

2. A comet is a body which moves round the sun, in a very eccentric orbit or tract, and is usually accompanied with a shining tail.

3. The orbit of any celestial body is the curve, or path it describes, in revolving round another. The orbits of the planets are elliptical.

4. The axis of a celestial body is an imaginary line, passing through it, about which it appears to revolve. The two extreme points of the axis are called poles.

5. The ecliptic is that curve which the earth describes, in revolving round the sun. It is divided into twelve equal parts, called signs.

6. The circle which encompasses the earth, at an equal distance from each pole, is called the equator.

7. The meridian of any place on the earth, is an imaginary circle, passing through the said place and the two poles.

8. Two celestial bodies are said to be in opposition, when they are in opposite points of the heavens.

9. Two celestial bodies are said to be in conjunction, when they are in the same point of the heavens.*

10. The elongation of a planet, is an angle formed at the earth, by two imaginary lines: one drawn from the planet. and the other from the sun, meeting in the earth.

11. A planet is said to move direct, or in consequentia, when it appears to move according to the order of the signs of the ecliptic.

12. A planet is said to move retrograde, or in antecedentia, when it appears to move contrary to the order of the signs of the ecliptic.

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* Astronomers consider two celestial bodies as being in conjunction, when their centres are in the same longitude, even where they have a small difference of latitude. *Editor.*

13. A planet is said to be stationary, when it appears to remain any particular time in a certain point of the heavens.

14. The horizon of any place is the circle which bounds the sight: this is called the apparent horizon.

15. The longitude of a planet, or star, is its nearest distance from the first point of Aries, measured regularly round the ecliptic.

16. The heliocentric longitude of a planet, is its longitude as viewed from the sun.

17. The geocentric longitude of a planet is its longitude as viewed from the earth.

18. The diurnal arc of any celestial body, is the arc it appears to describe from its rising to its setting.

10. The nocturnal arc of a celestial body, is the arc it describes from its setting to its rising.

20. The daily motion of any planet, is the portion of its orbit it traverses, or goes through, in a day.

21. The parallax of any celestial body, is the angle the semi-diameter of the earth forms or subtends at that body.

ASTRONOMY.

OF THE DIVISIONS OF THE CELESTIAL BODIES, WITH A DESCRIPTION OF "THE SOLAR SYSTEM."

1. ASTRONOMY is that branch of natural philosophy, which treats of, and describes, the appearances, properties, motions, magnitudes, periods, eclipses, distances, and the various phenomena of the celestial bodies.

2. The determination of the magnitudes, distances, and the orbits of the celestial bodies, is called *plane* or *pure* astronomy; and the investigation of the causes of their motions, is called *physical* astronomy.

3. Pure astronomy is determined from observations on the apparent magnitudes and motions of the heavenly bodies.

4. Physical astronomy is founded principally on analogy, by applying the laws of motion, to the observations of the planets and stars.

5. The celestial bodies are generally divided into two sections, viz. the solar system, and the universe.

6. The solar system is composed of a certain number of celestial bodies, which revolve round

the sun as a centre: they are divided into planets, comets, and asteroids.

7. The particular situations of these planets, comets, and asteroids, with respect to the sun, is the reason why the system is called "The Solar System," because they revolve round that luminary as a centre.

Obs.—The curve which each planet respectively describes in revolving about the sun, is an ellipse; and the sun is in a focus of such elliptic curve, Plate III. Fig. 1. If P e g d g′ P be any planet's orbit, S is the position of the sun.

8. The solar system is composed of the Sun, marked ☉ in the centre:

Of the seven primary planets, viz. Mercury ☿, Venus ♀, the Earth ⊕, Mars ♂, Jupiter ♃, Saturn ♄, and Herschell ♅:

Of four asteriods, or minor planets, named Ceres, Pallas, Juno, and Vesta.

Of eighteen secondary planets, satellites, or moons: the earth has one moon attending it; Jupiter has four; Saturn has seven; and Herschell has six:

And of a considerable number of comets.

9. The planets are divided into primary and secondary; they are also distinguished by the names of Superior and Inferior.

10. The primary planets are those bodies which revolve round the *Sun*, as a centre: they are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Herschell. Each planet, besides this revolution, has a motion on its axis; and the time it is revolving thereon, is the length of its day.

11. The secondary planets are those bodies which revolve round a primary as a centre; they are also called satellites or moons. The office of a secondary planet is, to reflect the light of the sun to its primary during the night, just as the moon reflects the light of the sun to us; the secondary planets have also a motion on their axes, by which means they have day and night in the same regular succession as we have.

12. The superior planets are Mars, Jupiter, Saturn, and Herschell; they are so called, because their orbits are *outside* the orbit of the earth.

13. The inferior planets are Mercury and Venus; they are so called, because their orbits are *within* the orbit of the earth.

14. The distances of the planets from the sun, their respective diameters in English miles, with the times of their various revolutions round the sun, in the days of our year, are as follow:

Planets.	Distance in millions of miles.	Diameter in miles.	Period in days.
Mercury - -	37	3,108	88
Venus - -	69	7,498	225
Earth - -	95	7,964	365
Mars - - -	145	4,444	687
Jupiter - -	494	90,145	4,332
Saturn - -	906	77,950	10,759
Herschell - -	1,813	34,404	31,346

OF THE SUN.

15. The sun is in the centre of the solar system, and from thence, by his genial rays, causes the planets to be fit habitations for created beings, and by means of his fructifying heat, they vegetate, for the animation and support of their various inhabitants.

Obs.—That the sun, moon, and planets are stored with inhabitants, we have every reason to believe, because they are as well provided with the means of supporting animals and inhabitants in general, as the planet on which we reside, has the inherent properties of providing sustenance for us; and there is no doubt, but that the all-wise Creator of the Heavens, has varied the constitutions of his family, so as to suit the respective planet he intends for them to occupy.

16. The sun is the only body in the solar system which shines by its own light. It is a large globe of 870,000 miles in diameter, and it performs a revolution on its axis, once in twenty-five days.

Obs.—The time the sun takes to revolve on its axis is determined, by observing the gradual motion of any particular spot on its surface; these phenomena were first observed by Galileo; and, as they revolve round the sun, as that body revolves on its axis, so if we notice how many days a particular spot is moving from one edge of the sun to the other opposite, so many days is half the time the sun is revolving on its axis, which being doubled, will be the time required.

17. The sun's apparent diameter is greater in *winter* than it is in *summer;* the earth is therefore nearer to the sun at the former, than at the latter period.

Obs. 1.—The sun's apparent diameter is the angle the diameter of the sun forms at the surface of the earth. This angle in December is 32′ 35″, and in June it is only 31′ 31″. The farther any body is from any particular place, the less angle it forms; and the nearer it it is, the greater angle it subtends; and, as the apparent diameter of the sun, is less in winter than it is in summer, we are consequently nearer that body at the former, than we are at the latter period.

2. The sun's diameter forming a different angle with us at different times, is a proof that the earth moves round the sun in an elliptical, and not in a circular orbit.

3. The reason why it is hotter in summer when the earth is farther from, than it is in winter, when it is nearer to the sun, is, because the sun's rays fall more obliquely on us in winter than they do in summer, and is also owing to the shortness of the days; just as if two persons are setting near a fire, one who sits before it receive the rays perpendicularly, while the other, who sits on one side, receives them obliquely; so the former receives more heat than the latter, even if he sit at a greater distance from the fire.

18. The appearance of the sun's daily rising in the east, and setting in the west, is occasioned by the revolution of the earth on its axis.

Obs. 1.—This optical illusion may be very readily reconciled, by imagining yourself to be in a coach, and looking out at the window, the hedges with their foliage, shrubs, &c. *seem* to be in motion, while you imagine yourself to be stationary; while it is the vehicle in which you are that is moving, and the hedges, trees, &c. which are stationary.

2. This illsuion may be farther illustrated, by recollecting that a person sitting in a boat, and looking steadily at the surrounding objects, will apparently observe the banks of the water, boats, &c. to be in motion, while the boat he is in, is to appearance stationary.

19. The sun was formerly supposed to revolve around the earth, as a centre; the earth

was *then* considered to be the centre of the system now called the solar system, but the observations of modern astronomers, have *proved* the sun to be in the centre, and the earth with the other planets, to revolve round it.

Obs.—The direct retrograde and stationary appearance of the planets, prove the planets to revolve round the sun.

20. The sun was also imagined to be a body of liquid fire, exhaustless in its nature, which, by emitting its rays in every direction, diffused light and heat through the system, but modern astronomers have, with greater plausibility, considered it to be a very eminent, large, lucid, solid body, shining by its own light, and by the effect or action of its rays upon other substances, causing heat and vegetation.

Obs. 1.—The sun is a *solid* body, because it revolves constantly and regularly round its axis, because that axis remains always in the same position, and because all bodies are attracted or gravitate towards it as a centre.

2. The action of the sun's rays upon substances *causing* heat, may be very readily imagined, by recollecting that the collision of a flint against a steel, not only causes heat, but produces fire; and the action of water upon lime, not only causes heat, but forces the water to fly off in steam.

21. The sun is surrounded by an atmosphere. which extends to about 2000 miles from its surface, but it is at least eighty times denser than the atmosphere surrounding the earth.

22. The disc, or face of the sun is also interspersed with spots, which appear occasionally, varying their number, size, and position. They

were first discovered by Galileo, and are divided into faculæ, or elevations of the luminous matter, and maculæ, or dark spots, which seem to be at the bottom of openings in the solar atmosphere.

23. The orbits of the planets, are the circular paths, which they describe in revolving round the sun, and all their orbits range in a circular space of the heavens, called the zodiac. See Plate VII. Fig 5.

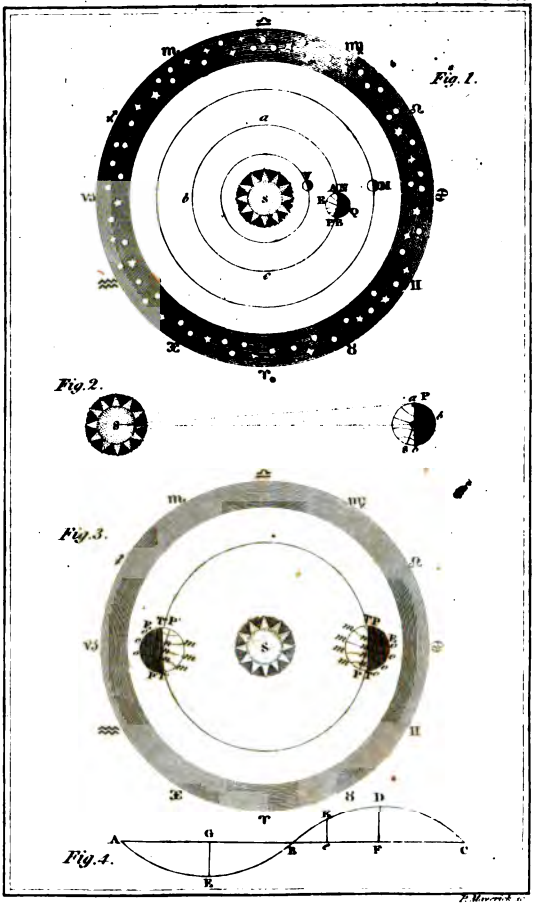
24. The zodiac, astronomers have, for conveniency's sake, divided into twelve parts, called and marked as follows: namely, Aries ♈; Taurus ♉; Gemini ♊; Cancer ♋; Leo ♌; Virgo ♍; Libra ♎; Scorpion ♏; Sagittarius ♐; Capricornus ♑; Aquarius ♒; and Pisces ♓; each extending 30°; and they are twelve constellations of stars, through which all the planets appear to move.

25. The orbit of the earth is called the ecliptic, and all the orbits of the planets are imagined to cross the plane of the ecliptic, in two opposite points, called nodes.

26. The zodiac extends 8° each side of the ecliptic, that is, no planet ever recedes farther than 8° from the plane of the ecliptic. The nearest distance of any planet, or of any celestial body, from the ecliptic, is called its latitude.

27. When it is noon, or twelve o'clock, at any place on the earth, the sun is then on the meridian of that place; and at midnight, the earth's place is in the opposite point of the heavens to the sun; that is, the point of the ecliptic on the meridian at midnight, is the earth's place.

Obs.—The place of any celestial body as seen from



P. Maverick sc.

the sun, is called its heliocentric or true place; and its appearance as seen from the earth, is called its geocentric or apparent place.

Obs. 1.—(Plate II Fig. 1.) Let ♈. ♉. ♊, &c. represent the plane of the ecliptic, let S represent the Sun, and the circle a, b, c, the orbit of the Earth, let NEPQ be the meridian of any particular place on the earth: then, as the Earth derives all its light from the Sun, the hemisphere of the Earth represented by AEPB, being towards the Sun, will be enlightened, and he would evidently appear to be in ♎ by a spectator on the earth, if ♎ were not hidden by his refulgence. This position of ♎ is called the Sun's place; and, as the portion or hemisphere of the Earth, represented by AEPB, will be in the position of ANQB at midnight, the portion of the Earth represented by that part, as is evident by the figure, is immersed in darkness, excepting such light as is derived from the stars and the superior planets; it is evident, then, that whatever portion of the ecliptic is opposite the meridian at midnight, is the Earth's place in the ecliptic as seen from the sun.

2. By carefully viewing the same figure, we readily perceive, that neither of the inferior planets can possibly be seen near midnight, but they may be viewed in the morning before sun-rising, or in the evening after sun-setting. If V represent an inferior planet, as Venus, it is evident that the enlightened portion of the Earth is *always* towards that planet; and therefore it is impossible for it to be seen from the dark hemisphere of the Earth, and consequently no inferior planet can possibly be seen in the night, and, therefore, if we see any planet near midnight, it must be a superior planet.

The time the sun appears to be traversing round the ecliptic, that is, the time the earth is revolving round the sun, is called a year, which is 365 days, 5 hours, 48 minutes, and 16 seconds.

Obs.—The time the Earth is revolving round the Sun may be easily observed, by noticing the sign and degree of the ecliptic, which is exactly south at midnight on any particular evening, and observing how many

days elapse before that very sign and degree are in the exact position again.

29. The sun is beautifully described by Thomson in his seasons.

"Soul of surrounding worlds! in whom best seen,
Shines out thy maker! may I sing of thee!
'Tis by thy secret, strong attractive force,
As with a chain, indissoluble bound,
Thy system rolls entire: from the far course
Of utmost Herschell, wheeling wide his round
Of eighty years, to Mercury, whose disc
Can scarce be caught by philosophic eye,
Lost in the near effulgence of thy blaze."

MERCURY.

30. Mercury is the first planet in the solar system, and the nearest to the sun; it revolves round that luminary with greater rapidity than any other planet, and for this reason the ancient Grecian astronomers considered it to be the messenger of the gods; they represented it with wings at its head and feet, from which is derived (☿) the character used to represent this planet.

31. The distance of Mercury from the sun is 37 millions of miles, and it revolves round that body in 87 days, 23 hours, 14 minutes, and 33 seconds.

32. Mercury is the *least* of all the planets, its diameter being only 3108 miles.

33. This is called an inferior planet, because it is nearer to the sun than the earth; for this reason it is seldom or never visible except in the darkest part of the twilight, in the morning, or evening, being always a near attendant of the sun.

It revolves on its axis in 24 hours, 5 minutes, 28 seconds.

34. This planet sometimes appears to pass across the sun; it is then apparently like a spot on his surface.

Obs. 1.—This is another proof that this planet's orbit is within the orbit of the earth, for if this planet's orbit were farther from the sun than the orbit of the earth, the sun might transit the planet, but the planet could not transit the sun.

2. The advantages derived to astronomy by the observation of transits, are particularly important. By them astronomers determine the Sun's horizontal parallax, or the angle the radius of the earth forms to a spectator placed at the Sun; and from the Sun's horizontal parallax, they readily determine the distance of the Earth from the Sun.

35. The orbit of Mercury crosses the plane of the ecliptic, in Taurus 15°, and in Scorpio 15°; that is, Mercury's ascending node is in ♉ 15°, and its descending node in ♏ 15°. Its greatest elongation is 28°.

Obs.—The earth is in ♉ 15° about November 6th, and in ♏ 15° about May 4th; so when Mercury passes those parts of its orbit on these days, it will transit the Sun, if it be in its inferior conjunction, or between the Earth and the Sun.

36. Mercury is thus described by Baker:

"First Mercury, amidst full tides of light,
Rolls next the Sun, thro' his small circle bright.
All that dwell here must be refin'd and pure,
Bodies, like ours, such ardour can't endure;
Our earth would blaze beneath so fierce a ray
And all its marble mountains melt away."

VENUS.

37. This is the most brilliant of all the planets. When she appears in the morning, she is denominated the morning star; and when she is visible in the evening, she is called the evening star.

38. Venus is of a beautiful white colour, and so brilliant, as frequently to cause the objects upon which she shines to cast a shadow.

39. Venus is the other of the inferior planets; and as her orbit is within the orbit of the earth, she is never visible to us in the night. She turns on her axis once in 23 hours, 21 minutes.

40. Venus is an evening star, or to the east of the sun, for 290 days, during which period she is poetically called Hesperus, or Vesper; and she is west of the sun during a similar period, and is then called Phosphorus, Lucifer, or the Morning Star.

41. The planet Mercury appears to the inhabitants of Venus, in the same situations that Venus appears to us, being sometimes a morning, and sometimes an evening star.

42. Venus sometimes transits the Sun, and she is then seen as a spot on its surface. The next transit of Venus will be on December 8, 1874.

43. The orbit of Venus intersects the plane of the ecliptic in ♊ 15°, or ♌ 15°; and in ♐ 15°, or ♓ 15°, which are her ascending and descending nodes.

44. Venus revolves round the sun in 224 days, 16 hours, 49 minutes, 11 seconds at a mean

distance of 68 millions of miles. When viewed through a telescope, she presents phases like the moon; this was first discovered by Galileo, with a telescope made by him with the barrel of an organ. The greatest elongation of Venus is about 48°.

45. Venus is thus poetically described by Baker:—

"Fair Venus next fulfils her larger round,
With softer beams, and milder glory crown'd:
Friend to mankind; she glitters from afar,
Now the bright evening, now the morning star.

THE EARTH: WITH ITS SATELLITE, OR MOON.

The Distance of the Earth from the Sun, with its Shape and Magnitude.

46. The earth is the third planet in the solar system, and it revolves round the sun between Venus and Mars.

47. The distance of the Earth from the sun is 95 millions of miles, and in its revolution, is attended with a satellite or moon, which is designed to reflect to us the light of the sun during the gloomy hours of night.

Obs.—The distance of the Earth from the Sun is determined in the following manner.

Plate II. Fig. 2. Let S′ represent the Sun; Pa Sb, a meridian of the Earth, O its centre, and acb′, a parallel of latitude or almacantar: at a the Sun appears in the horizon; let a S′ and S′ o be united; then when S′ is in

the horizon, the triangle S′ a o is right-angled at a. Then in the right angled triangle, O a S′, are given, the angle S′, equal to 8″, equal to the Sun's horizontal parallax: and the side a o, equal to the semi-diameter of the Earth, equal to 3982 miles: to determine the side a S′. That is, by trigonometry: as sign ∠S′: a o :: sine △ S′ O a = △ co-sine △S′: a S′= the distance required.

48. The earth in shape is round, like all the other planets. As the small protuberances on the rind of an orange, disappear at the distance of a few feet, so the mountains and valleys on the earth's surface, being small in proportion to its bulk, would not prevent its circular appearance, when viewed at a great distance.

Obs. 1.—That the Earth is round is evident, first because in eclipses of the moon, which are caused by the moon's passing through the earth's shadow, that shadow is circular on the moon's surface, consequently the body which casts a circular shadow must be globular, and therefore the earth is round.

2. Another proof of the rotundity of the earth is, that it has been sailed round by various circumnavigators: they have sailed from particular ports, and by continuing their course in one direction, have arrived at the port first sailed from.

The first navigator who sailed round the world, was Ferdinand Magellan, a native of Portugal. He sailed from Seville in Spain, on the 10th day of August, 1519, and performed his voyage round the world in 1124 days, arriving at St. Lucar, near Seville, on the first of September, 1522. He was the first who sailed through the Straits which separate Patagonia from Terra del Fuego, in South America; and they have on that account been called "The Straits of Magellan." Since that period, the globe has been sailed round by various navigators, among whom are Sir Francis Drake, Lord Anson, Captain Cook, &c.: and this also proves the earth to be globular.

49. The diameter of the Earth is 7964 miles, and its circumference 25,020 miles, which circumference is divided into 360 equal parts, called degrees, like the circumference of every circle.

Obs.—The circumference of the earth has been most accurately determined by various mathematicians. Our countryman, Mr. Richard Harwood, measured a degree between London and York, which degree he found to contain 69½ English miles. This distance multiplied by 360, gives 25,020 miles for the exact circumference; and this divided by 3.1416, produces 7964 miles, which is its diameter.

The earth's mean diameter, has lately been ascertained to be about 7920 English miles. *Ed.*

Of the rotary and orbicular Motions of the Earth.

50. The Earth, like all the other planets, has a two-fold motion; it turns round on its axis, while it is proceeding gradually in its orbit round the Sun.

51. By the rotation of the Earth on its axis, is caused that regular succession of day and night, so wisely adjusted by the omnipotent Creator, as the seasons for labour and rest.

53. By this motion, the Sun, and all the heavenly bodies *appear* to approach the horizon, to rise, to ascend until they have reached their meridian splendour; to decline, and, at last to sink in the western sky.

53. This revolution of the earth on its axis, is performed regularly in 23 hrs. 56 m. 4 sec.

Obs.—The length of the natural day is twenty-four hours; for, while the earth is gradually turning on its axis, it is majestically proceeding in its orbit; therefore, the time which elapses from the sun's being on any me-

ridian, on one day, until it appears thereon again, is twenty-four hours; called a natural day.

54. The motion of the earth on its axis is from west to east; because stationary bodies, as the sun and stars, appear to rise in the east, to attain the meridian, and to set in the west.

55. The axis of the earth is inclined from a perpendicular to the plane of the ecliptic, $23\frac{1}{2}°$; and in consequence of this inclination, the days and nights are continually varying in length.

Obs.—To illustrate this, (Plate II. Fig. 3.) let S be the sun; E E′ the earth in two different positions of its orbit; let P P and P′ P′ be the axis of the earth in its positions E and E′, inclined $23\frac{1}{2}°$ from a perpendicular, m n o, m n o, small circles, perpendicular to P P, and parallel to each other; T T, T′ T′, perpendicular to the horizon. Now it is evident that the portion of any body over which a light shines, will be enlightened; and this enlightened portion, in a globe like the earth, will be one half, or a hemisphere. The lines T T, T′ T′, which divide the light from the dark hemisphere, are called terminators. As the parallels m n o are drawn to intersect TT, T′ T′, in n, n, &c. so will TT divide m n o into two unequal parts, m n, n o.

When the earth is at E, the sun's rays do not enlighten the north pole P, as is evident by the figure; consequently the inhabitants of that region are enveloped in darkness, while the inhabitants of the southern regions, around the south pole P′, have the advantages of continual day-light. And the proportion of day to night, on any place of the globe, is as the portion of any of the parallels m n to n o; the earth is in this portion of its orbit, December 21st. So when the earth is at E′, the opposite part of its orbit, the north pole P′ will have the sun constantly shining over it, while the south pole will be enveloped in gloom; the earth is so situated on June 21st: and as the lengths of the days to the lengths of the nights are always as the portions of the parallels

m n to n o, so they are unequal all over the earth E, excepting at the equator, where the terminators bisect the axis: therefore the cause of the inequalities of the lengths of the day and night is the inclination of the axis of the earth, from a perpendicular 23½°, to the plane of its orbit.

56. The different seasons of the year are occasioned by the different lengths of the days and nights.

Obs.—The longer the days are, at any particular spot on the earth, the hotter that spot is; and the shorter the days are, the colder it is; and as the warm or cold seasons are occasioned by the heat or coldness of the earth, so those are evidently occasioned by the different lengths of the day and night, or, which is the same thing, by the inclination of the axis of the earth.

57. The earth has a motion in its orbit, called its orbicular motion, as well as a motion once in twenty-four hours on its axis.

58. This motion in its orbit is progressive, and it revolves round the sun, from any particular portion of the ecliptic, until it arrives there again, in a year, or 365¼ days.

59. The ecliptic is divided into twelve parts, called signs, each containing 30°, and each degree is subdivided into sixty minutes, and so on.

Obs.—The circumference of *every* circle is divided into 360°, each degree into 60 minutes, each minute into 60 seconds, &c. &c.

60. The motion of the earth in the ecliptic is unequal, owing to its being elliptical. The summer half year is therefore eight days longer than the winter half year.

61. The ecliptic is frequently called the *sun's* path, because it is the track he *appears* to describe among the fixed stars.

62. It is called the ecliptic, because all the eclipses of the sun or moon, happen when the moon crosses it, or is nearly in one of those parts of her orbit where it crosses it, which points are the moon's nodes.

63. The angle which the plane of the ecliptic makes with the plane of the equator, is called the obliquity of the ecliptic, and is equal to $23\frac{1}{2}°$.

64. When the earth is in that portion of its orbit where both the north and south poles receive the sun's rays at the same time, it is then said to be in the equinoxes. This happens when the sun enters the constellations Aries and Libra; and the first points of Aries and Libra are called the equinoctial points. The equinoctial points have a motion of $50\frac{1}{4}$ seconds in a year, backwards, or from east to west. This motion is called the precession of the equinoxes.

65. The day is equal to the night all over the earth at the time of the equinoxes, which are on March 20th, and September 23d; but on every day in the year, excepting these two, the day is unequal in length to the night all over the earth, excepting at the equator, at which place the days and nights are always equal.

66. On the longest day in a northern latitude, the sun shines $23\frac{1}{2}°$ over the north pole; and on the longest day in a southern latitude, the sun's rays enligthen a space of $23\frac{1}{2}°$ over the south pole: these days are June 21st, and December 22d. called solstitial days: and the portions of the ecliptic in which the earth is, on those days, which are the begining of Cancer and of Capricorn, are named solstitial points.

Obs.—The length of the longest day in a northern or southern latitude, is equal to the length of the longest night; and when the day is the *longest* in a northern latitude, the day is the *shortest* in the southern; and when the day is the *shortest* in a northern latitude, it is the *longest* in a southern.

67. The earth is in the beginning or first point of Aries, September 23d; of Taurus, October 23d; of Gemini, November 22d; of Cancer, December 22d; of Leo, January 21st; of Virgo, February 19th; of Libra, March, 20th; of Scorpio, April 20th; of Sagittarius, May 21st, of Capricornus, June 21st; of Aquarius, July 23d; of Pisces, August 23d.

68. The eliptic being inclined in an angle of $23\frac{1}{2}°$ from the plane of the equator, the earth, in passing round the ecliptic, must be at different distances from the plane; the nearest distance from the plane of the equator to the sun is the earth's declination, commonly called the sun's declination.

Obs.—To illustrate this, (Plate II. Fig. 4.) let AGBFC be the plane of the equator and the sun; A E′ B D C the ecliptic, intersecting the former in B and A, making the angles DBF; DCF; GAE′; E′BG, each equal to $23\frac{1}{2}°$; imagine the points A C to be united, so shall AGBC; AE′BDC be two circles. Now when the earth is at A and B, it has no declination, the days and nights are then equal all over the earth, which happens on March 20th and September 23d the day and night each being equal to 12 hours. Let the earth be at E, any particular situation of the ecliptic, then the perpendicular E e being drawn, E e being the nearest distance from E to any part of ABC, is the earth's declination when it is at E; let E be placed in what part soever it may of AEBDC. When the point E coincides with D, the declination is the greatest, and DF is equal to $23\frac{1}{2}°$; equal to the angle DBF.

69. The declination is the greatest at the solstices; and the least, or nothing, in the equinoxes.

Divisions of the Earth, or the five Zones explained.

70. The inclination of the axis of the earth, causes the sun not to shine on a certain portion of its surface at one season of the year; this portion of the earth is called a frigid zone.

71. As the earth has at one season of the year, a portion of its surface, extending 23½° from the north pole; and at the opposite season, a similar portion of its surface, surrounding the south pole, deprived of the rays of the sun; there are consequently two frigid zones.

72. That portion of the earth which receives the rays of the sun in a perpendicular direction, is called the torrid zone. This zone extends 23½° each side of the equator, making an extent of 47° in breadth.

73. The portions of the earth which every day in the year are enlightened with the sun's rays, but which never shine perpendicularly thereon, are called temperate zones. There are two temperate zones, and the whole number of zones is five; namely, one torrid, two temperate, and two frigid.

74. The circles which bound the torrid zone, are called tropics; that bounding it on the north, is called the tropic of Cancer, and that bounding it on the south, the tropic of Capricorn.

75. The circle which bounds the north frigid zone, is called the Arctic circle, and that which

bounds the south frigid zone, the Antarctic circle; these circles are frequently called Polar Circles.

The atmosphere of the Earth with its various Phenomena.

76. The earth is surrounded with a thin, elastic, transparent, and invisible fluid, called the Atmosphere.

77. The atmosphere contains within itself the principles of life and animation, as none of the inhabitants of the earth, not even vegetables could exist, without enjoying its genial influence.

78. It extends to about fifty miles from the earth's surface, and the further it is therefrom, the more rare and thin it is.

79. The atmosphere is not only essential to us, by its containing the principles of life, but it is necessary for our comfort, by causing the light of the sun to be seen after he has descended the western, and before he arises in the eastern horizon. This faint light before sun-rising, and after sun-setting, is called the Crepusculum, or the Twilight. This twilight commences in the morning, and ends in the evening, when the sun is 18° perpendicularly below the horizon.

80. The earth is not only *surrounded* but every square inch of its surface is *pressed* by the atmosphere, with a power of fourteen pounds and a half.

81. The atmosphere is the grand source of rains and dews, which moisten and fertilize the earth. Without it there would be no day, as

the sun would, without the atmosphere, appear an immense large fiery globe where he was visible, and the places on which his rays did not shine, would be immersed in gloom.

82. The atmosphere attends the earth in its motions, and its gravity is about a thousand times lighter than water.

83. The air being acted upon by the attractions of the sun and moon, has tides generated in it, just as the sea has, and this is probably the reason why its temperature is more changeable at the new and full moon, than it is at other times.

84. The air is rarefied by heat, and condensed by cold; that is, the same quantity of air will occupy a greater or lesser space, according to its density.

Obs.—This may be very easily proved, by filling a bladder with air, and tying its neck so secure that none may escape: If this bladder be exposed to the heat of fire, it will, as the air contained therein rarefies, expand the bladder, and at length burst it with a great report.

85. The atmosphere is likewise essential to the inhabitants of the earth, in rarefying and sustaining the various effluvia emitted from its surface.

Obs.—The various noxious vapours which are generated on the earth, ascend through the atmosphere, until they arrive at that part, the specific gravity of which, is equal to the specific gravity of the ascending vapours.

86. The various vapours and effluvia which arise from the earth, float in the atmosphere, and are called clouds; and they are of different

Fig.1.

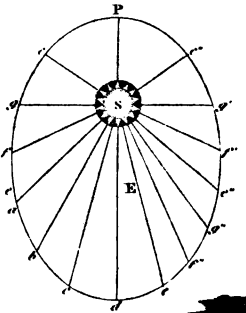


Fig.2.

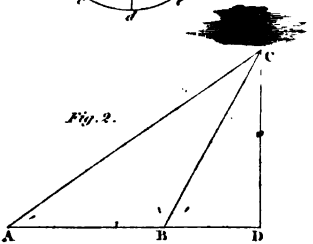
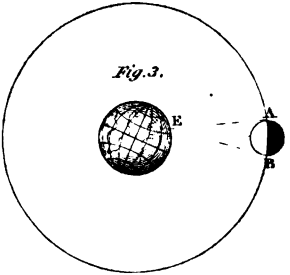


Fig.3.



heights, according to their specific gravity or weight. Clouds are scarcely ever more than two miles high, and very frequently not more than five or six hundred yards.

87 The diversified shapes of the clouds is owing to their loose texture, and their different colours are occasioned by their particular situations with regard to the sun, combined with the quantity of aqueous particles they contain.

Obs.—The altitude of any particular cloud may very easily be ascertained, thus—

Plate III. Fig. 2. Let C be any particular part of a cloud; let A and B be any two stations on the earth; let two people at the same instant take the measure of the angles CAB and CBD. Then, in the triangle ACB, are given AB and all the angles, to find BC; and in the triangle BCD are given all the angles, and BC, to find DC, which will be the height of the cloud required. Thus if the angle A be 35°, the $\angle CBD = 64°$, and the distance AB 880 yards; the altitude of the cloud DC = 936 yards nearly.

88. When the clouds are increased by a continual addition of vapours, and their particles are driven close together, by the force of the surrounding atmosphere, they have a very dark appearance, and are generally very low; and when they are too heavy for the atmosphere to sustain, they descend copiously on the earth in drops of rain.

89. The drops of rain increase in size and motion in their descent; so that a bowl placed on an eminence, will receive a considerably less quantity of rain, than one placed on the earth's surface, during the same shower.

90. The atmosphere is also the grand reservoir of dews, which so liberally replenish the earth; and in many countries, as Chili, Egypt, &c. supply the want of rain.

91. The dew does not descend from the clouds in the same manner as rain; but as the rays of the sun heat the earth; so, when he has declined the western horizon, a number of particles evaporate from its surface, and ascend into the surrounding asmosphere, where the coolness of the air condenses them, and causes them to fall in very minute drops; and thus is formed that universal means of fertility, dew.

92. The hotter the day has been, the more particles will evaporate in the night, and consequently the heavier will be the dew. This is the reason why the dews are greater in hot countries, than they are in cold ones.

93. When the atmosphere is filled with vapours, and a cold breeze arises, which prevents their ascending and uniting, clouds are formed in the *lower* parts of the atmosphere, which low clouds are called mists or fogs.

Obs.—The earth is generally accompanied with a mist on a cold morning, but as the rays of the sun begin to enlighten and warm the atmosphere, it disperses, and forms clouds in the higher regions of the air.

OF SNOW, HAIL, LIGHTNING, THUNDER, FALLING STARS, AND THE AURORA BOREALIS.

94. When the clouds are frozen before their particles are united into rain, small portions of them being united and made heavier by such condensation, they will descend in flakes of SNOW.

95. Hail is a compact mass of frozen water, consisting of drops of rain frozen in their descent from the clouds to the earth.

96. As the atmosphere is the receptacle of all the effluvia which rise from the various bodies on the earth's surface; so, when clouds composed of nitrous and sulphureous substances meet, they produce a strong conflict, and fire is emitted therefrom, which is called lightning.

97. The noise accompanying this ignition of sulphureous substances is called thunder; and the clouds being thus decomposed, torrents of rain generally follow.

Obs. The distance we are from the clouds, from which the lightning proceeds, may be very readily calculated. For as sound moves 1142 feet in a second, if the number of seconds elapsing between the sight of the lightning, and the report of the thunder be multiplied by 1142, it will give the distance of the cloud required, in feet.

98. When the clouds which thus explode are very low, steeples, high trees, or any thing that stands in a prominent situation, is liable to be injured or destroyed by the ignited particles.

99. The atmosphere is likewise interspersed with vapours, which coalesce according to their nature. Some of the particles appear like stars,

and fall from a higher to a lower situation, and are then called falling stars.

100. The aurora borealis is supposed to be occasioned in the higher portions of the atmosphere, where there are particles of inflammable matter, which are ignited by electricity.

THE DIVISIONS OF THE BODY OF THE EARTH.

101. The *solid* body of the earth is divided into three sections, viz. First, the exterior; secondly, the interior; and thirdly, the middle section.

102. The exterior portion is the part on which vegetables, plants, trees, fruits, &c. &c. are generated and grow; this is wisely ordered by the great Creator, for the support of its numerous inhabitants.

Obs. 1.—The external or corticle part of the earth is composed of hills, valleys, mountains, and plains, and with various beds or layers of strata, which are generally interspersed with respect to each other, according to their specific gravity or weight, the heavier being below, and the lighter above.

2. These inequalities in the surface of the earth are supposed to have been occasioned by the concussion and agitation of the various parts of the earth, at the universal deluge, when the world seems to have been convulsed; but as the water subsided, and flowed into the deepest pits, the other portions of matter were collected together, according to their specific gravities.

103. The middle or intermediate portion is possessed by fossils, as quarries of stones, mines of metals, salt, coal, &c. &c., all necessary for the comfort and convenience of mankind.

104. The internal portion of the earth is sup-

posed to be composed of a solid mass of different sorts of metals, stones, &c., but which can never be explored by human labour.

Obs.—That the internal portion of the earth contains metals in very great proportion is very plausible, for the eminent Dr. Hutton, from many ingenious experiments, proves the mean density of the earth to be $\frac{1}{5}$ as heavy as common stone; its interior must, therefore, be composed of substances of very great density, which we have every reason to conclude is metal.

OF TIME.

Of the Natural, Astronomical, or Solor Day; of the Sidereal Day; and of the Equation of Time.

105. The period the earth takes to revolve on its axis, that is, one revolution of the earth, is called a day.

106. The day has been divided by mankind into 24 parts, called hours; each hour into 60 parts, called minutes; each minute into 60 seconds, and so on to thirds, fourths, &c.

107. This period of 24 hours is called a solar, astronomical, civil, or natural day, because it is the time which elapses between the sun's being opposise any meridian, before it appears to return to the same meridian again.

108. The sidereal day is the time which elapses between the appearance of any fixed star on any meridian, until its apparent return to the same again, and consists of 23 hours, 56 minutes, 41 seconds.

109. The sidereal day is the exact time the earth takes to revolve on its axis, and is determined by observing the period which elapses between the same fixed star coming twice to any particular meridian.

110. The difference between the solar and sidereal day, is occasioned by the motion of the earth in its orbit, during one revolution on its axis; to an inhabitant on the earth, the sun appears to have changed its place to the eastward in the same time, as much as the earth has: the daily difference of the sun's longitude, reduced to right ascension, will therefore be the quantity, by which the solar day exceeds the sidereal. This quantity varies about 3 m. 35.3 sec. to 4 m. 26.8 s.

111. Because the earth moves in an elliptic, and not in a circular orbit, its motion in some parts of that orbit is quicker than it is in other parts; and, as the solar day is the time of the sun's appearing on any meridian, to its apparent return to the same again, the solar or natural day is consequently shorter at some seasons of the year than it is at other seasons.

Obs. 1.—The earth (as well as the other primary planets) moves round the sun in an elliptic, and not in a circular orbit, having the sun fixed in a focus, and the secondary planets revolve round their respective primary planets likewise in elliptic orbits; the primary of each being in a focus of the ellipse the secondary describes.

2. (Plate III. Fig. 1.) If S represent the sun, g f e', &c. &c. the elliptic orbit of the earth, the spaces or areas g S f, f S e', &c. described by the earth in equal times, are equal, (this motion of the earth was first discovered by Kepler, a very eminent astronomer of Germany.)

And as these areas will depend in some measure on the length of the lines Sg, Sf, Sa, Sb, &c. the length of the curves gf, f e′, e′ a, &c. will be longer or shorter, as the distances bS, aS, fS, &c. are increased or diminished; and if we imagine the spaces a e′, e′ f, f g, &c. to be passed over by the earth in a day, the inequality in the lengths of the solar days may be very easily conceived.

112. Astronomers consider the period the earth is revolving round the sun, to be equally divided into hours; twenty-four of which they call a day; this is called *mean time*, or the time shown by a well regulated clock.

113. The difference between mean time, or the equal division of the year; and the solar day, or the time which elapses from the sun's being on one meridian, to its appearance there again, is called *equation of time*.

114. The time shown by a good sun-dial is solar time, and if to that we add or subtract the equation of time, we shall have mean time.

Obs. 1.—In common language, a day is the term applied to the space of time between the rising and setting of the sun. This is an artificial day.

2. The astronomical day commences at noon, and is reckoned onward regularly until the noon following.

3. From noon to midnight the hours are frequently distinguished by the letters P. M., and from midnight to noon by A. M.

4. The day begins with different nations at different times. England, France, Spain, and other parts of Europe begin their day at midnight. In some parts of Germany and Italy they begin their day at sun-setting, and reckon onward until the sun sets again; so did the Jews, the Romans and the Turks. The Babylonians began their day at sun-rising.

THE MOON.

The Offices, Distance, Magnitude, &c. of the Moon.

(Plate IV. Fig. I.)

115. Next to the sun, the moon is the most splendid and brilliant orb we observe in the heavens; and, by her dissipating the gloom of darkness, she is not only pleasing, but a welcome and useful companion in our tedious nights.

116. The moon is a solid opaque body, having no light of her own, but reflecting the light she derives from the grand luminary of day; and she is like all the other planets, of a globular form.

117. The moon is a satellite, or secondary planet of the earth, revolving round it in the same manner as the earth revolves round the sun, in an elliptic orbit, the earth being in a focus of the elliptic curve.

118. The moon, to a spectator ignorant of the celestial bodies, is considered one of the largest in the heavens, but it is her comparative nearness to us, which causes her to appear so large and bright. She is 2161 miles in diameter.

Obs.—The diameter of the moon is ascertained thus; the moon's diameter to a spectator on the earth makes an angle of 31′ 7″.

(Plate III. Fig. 3.) Let E represent the earth, AB the diameter of the moon, AE=BE=the moon's distance from E the earth. Then the $\angle EAB = \frac{180 - 31' 7''}{2} = 89°$

THE COMET OF 1819. *Fig. 1.* *Pl. 4.*

44′ 26½″=∠EBA. And in the triangle EAB are given ∠ABE=∠BAE and AE; to find the side AB; that is, as, S∠EBA : AE :: S∠E : AB, as required.

119. The axis of the moon is inclined from a perpendicular 1° 43′ to the plane of its orbit.

120. The distance of the moon from the earth is 240,000 miles.

Obs.—The distances of any of the planets, or the moon, from the earth, is readily ascertained by their horizontal parallaxes, in the same manner as the distance of the earth from the sun is determined by the sun's horizontal parallax.

Of the orbicular and rotary Motions of the Moon.

121. The motion of the moon round the earth is from west to east, in the same direction as the earth revolves round the sun.

Obs.—This fact will appear evident by observing a solar eclipse, which is occasioned by the moon's passing between the earth and the sun; the western edge of the sun will be first obscured, and the eastern edge last; consequently the motion of the moon must be in that direction, or from west to east.

122. The moon makes a complete revolution round the earth in 29 days, 12 hs. 44 min., and this is the time from one new moon to another, called a synodical month, or lunation. She revolves on her axis exactly in the same time, and this period is therefore the length of her day.

Obs.—This is proved by observing the spots on her surface; as they always appear in the same position, it

is therefore evident that she turns on her axis in the same time she revolves round the earth.

123. As the earth turns round daily on its axis, the inhabitants of the moon will distinctly see the mountains, islands, &c. on the earth, as so many spots on its surface.

Obs.—The utility of the appearance of these spots, to the inhabitants of the moon, will be to measure their time, and will serve them the same purpose as a sun-dial serves us.

124. The time the moon is revolving round her orbit, from any fixed star, until it arrives at the same again, is 27 days, 7 hs. 43 min. 8 sec.; this is called a periodical month.

Obs.—The reason why the synodical is longer than the periodical month, is, because while the moon is revolving round the earth, the earth is proceeding round the sun; so that from one conjunction of the sun and moon to another conjunction, the earth has moved about one sign, or 30° in the ecliptic; consequently $1\frac{1}{12}$ periodical month is *nearly* equal to a synodical month.

Of the various Appearances of the Moon.

125. At the time of the new moon, she is then directly between the earth and sun; this is called a conjunction of the sun and moon, and is marked ☌; she is then at her nearest distance to the sun.

Obs.—(Plate V. Fig. 1.) The moon has been beautifully described by Pope in his translation of the Iliad of Homer:

When the full moon, refulgent lamp of night,
O'er heaven's clear azure spreads her sacred light:

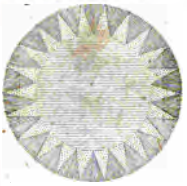


Fig. 1.

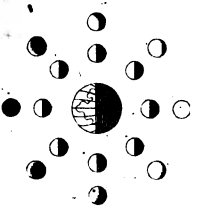


Fig. 2.

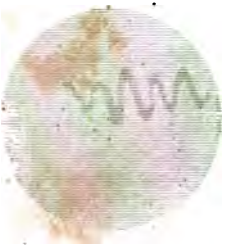


Fig. 3.

Fig. 1. The Phases of the Moon.
Fig. 2. and 3. The Telescopic Appearances of Mars.

When not a breath disturbs the deep serene,
And not a cloud o'ercasts the solemn scene;
Around her throne the vivid planets roll,
And stars unnumber'd gild the glowing pole.
O'er the dark trees a yellow verdure shed,
And tip with silver ev'ry mountain head;
Then shine the vales, the rocks conspicuous rise,
A flood of glory bursts from all the skies;
The conscious swains rejoicing in the sight,
Eye the blue vault, and bless the useful light.

126. At the time of full moon the earth is between the sun and moon; she is then said to be in opposition to the sun, which opposition is marked *8*: she is then at her greatest distance from the sun.

127. The conjunction and opposition of the moon are very frequently called syzygies.

128. As the moon derives all her light from the sun, she has, at her conjunction, her dark hemisphere toward the earth, while her enlightened portion is toward the sun; she is then invisible to us; but at the time of her opposition her dark hemisphere is from the earth, and her enlightened portion toward the *earth*, as well as toward the sun.

129. At the full moon, she appears to rise as the sun appears to set, and to come on the meridian at midnight; majestically declining, she descends the western horizon, as the sun ascends the eastern.

130. The various appearances of the moon from new to full moon, are called phases, and are occasioned by a smaller or greater portion of her enlightened surface being visible to us.

131. As the moon increases from her conjunction to her opposition, she will present to our view a variable portion of a circle, the visible portion of the circumference of which will be toward the west.

132. When she arrives half way between her conjunction and opposition, she appears like a semicircle; when increasing, or in her first quarter, the visible portion of her circumference is toward the west, and when dereasing, toward the east.

Obs. 1.—As the moon revolves round the earth, the earth to the inhabitants of the moon, appears to revolve round her. The earth appears above their horizon the period of one half a lunation, and the period of the other half it is invisible to them. The earth is the largest and most beautiful object in the heavens to them; and by transmitting the sun's rays, dissipates the gloom of their night.

2. At a new moon, the sun is visible to one half of the moon, and the earth shining in full splendor, visible to the other half: and at a full moon one half of the moon is immersed in darkness, while the other half is enlightened by the sun. The earth presents to the moon the same kinds of phases that she presents to the earth, only the phases of the earth are considerably larger and more resplendent.

133. As the moon revolves round the earth in 29 days, 12 hours, 44 min., and as the circumference of her orbit is 360°, her mean motion is 12° 11' each day.

134. The orbit of the moon makes a variable angle from 5° to 5° 18′ with the plane of the ecliptic. The two points where her orbit is imagined to cross the ecliptic are called the moon's nodes.

135. The moon's nodes move retrograde, or contrary to the order of the signs, 19° 19' 44" every year.

136. When she appears to pass over any planet or star, such planet or star is said to suffer an occultation. The occultations of the stars are useful in determining the longitudes of places, in the same manner as *eclipses* of the moon are.

Of the Spots or Mountains of the Moon.

137. The surface of the moon is interspersed with hills, valleys, volcanoes, &c. like the earth, to which astronomers have, for conveniency's sake, given names. The altitudes of the lunar mountains have been determined by Dr. Herschell and others, by means of their shadows, on the surface of the moon.

138. The moon is surrounded with an atmosphere; but it is much rarer than the air encompassing the earth, her enlightened surface being always visible through it.

139. Any terrestrial body being removed to the moon, would only weigh one third as much as it does at the surface of the earth; therefore the moon's atmosphere must be at least three times rarer than our air.

The Harvest and Horizontal Moon.

140. The full moon which happens at, or near the autumnal equinox, is callled "The Harvest Moon," because it rises for several evenings following nearly at the same time; by which

means it diffuses its cheering light, to aid the husbandmen to gather in the harvest.

Obs.—This is occasioned by the ecliptic's (and consequently the moon's orbit) making the greatest angle with the horizon at that season.

141. The moon and all the heavenly bodies, appear larger when near the horizon, than they do as they ascend towards the zenith. This appearance of the *moon* is denominated "The Horizontal Moon."

MARS.

(Plate V. Figs. 2. and 3.)

142. Mars is the fourth planet in the solar system, and is situated between the orbits of the earth and Jupiter.

143. This is in appearance the darkest and least splendid of all the planets; it is of a dusky red hue. Bright spots have been observed near its poles, which are supposed to be occasioned by those regions bing covered with ice or snow.

144. The dusky red appearance of Mars, is, according to many astronomers, owing to a thick atmosphere with which it is surrounded.

145. From the red appearance of this planet, it is denominated Mars, or the God of War, and is represented by this character ♂, denoting a man with a spear in his hand. The same character is used to represent iron among metals.

146. Because Mars is sometimes opposite the meridian at midnight, his orbit is evidently outside the orbit of the earth, (Obs. 2. Art. 27.), and he is the nearest of the superior planets.

147. The distance of Mars from the sun is 145 millions of miles. His orbit makes an angle of 1° 52' with the plane of the ecliptic.

148. Mars is 686 days 23 hours revolving round the sun: he turns on his axis in 24 hours 40 minutes: this Dr. Hook and Cassini first discovered by the gradual motions of his spots. His axis is inclined from a perpendicular, 59° 22' to the plane of his orbit.

149. The diameter of Mars is 4444 miles. The place of his ascending node is ♉ 17° 17', and that of his descending node ♏ 17° 17'. His horizontal parallax is 30", from which his distance from the earth or sun is readily determined. (See page 79.)

150. The analogy betwen Mars and the Earth, is by far the greatest of any two planets in the whole solar system.

151. The inhabitants of Mars have three inferior planets, Mercury, Venus, and the Earth. Each of these will sometimes be a morning, and sometimes an evening star; although the Earth will be the brightest and the most luminous object they can behold.

JUPITER.

(Plate VI. Fig. 1.)

152. Jupiter is the fifth planet in the solar system; it is situated between the orbits of Mars and Saturn, at a distance of 490 millions of miles from the sun.

153. This is the largest planet in the solar

system, its diameter being 90,145 miles; it is in appearance of a beautiful bright, white lustre, and on that account is denominated a morning, or an evening star, according as it is west or east of the sun.

154. This planet for his superiority among the planets, is called Jupiter, as *he* was the mightiest of the heathen deities. He is represented by this character ♃, to denote his whiteness; the same is used to distinguish tin among metals.

155. Jupiter revolves round the sun in 11 years, 314 days, or 4332 days. Its orbit makes an angle of 1° 20' with the plane of the ecliptic.

156. Jupiter's ascending node is 8° of ♋, and his descending node 8° of ♑.

157. The sun appears to us nearly five times as large as it does to the inhabitants of Jupiter, consequently they receive only one twenty-fifth part of the light and heat we derive from that luminary.

158. To compensate for this defect of light, our bounteous Creator, who is ever attentive to the comforts of His creatures, has accommodated Jupiter with *four* satellites or moons, which majestically revolve around it, and thus cheer his gloomy nights.

159. The night, to the inhabitants of this superior planet, is never so long as five hours, because it revolves on its axis in 9 hours 56 minutes.

160. The axis of Jupiter is nearly perpendicular to the plane of his orbit, consequently the length of his days and nights are nearly equal all

over its surface; this is another wise provision of its Creator, for if its axis were much inclined, one portion of its body would alternately be deprived of the sun's light, and have constant day for nearly the space of six years.

161. The surface of Jupiter appears to be encompassed with various streaks, which are called belts; they are parallel to its equator, though they frequently change their situation; they are thought to be clouds floating in its atmosphere; its surface is also interspersed with spots.

The Satellites of Jupiter.

162. The satellites of Jupiter are too minute to be observed by the naked eye, but with a telescope they present a very majestic appearance.

Obs.—The satellites of Jupiter remained undiscovered in the earlier ages of astronomy, when the science was cultivated without the assistance of magnifying glasses; but in the year 1609, by the help of a telescope, Simon Marius, a German mathematician, first discovered these satellites, and, in the ensuing year, they were observed by Galileo.

163. The advantages which are derived to astronomy from this discovery are very considerable; their eclipses prove that light is progressive in its motion, and does not arrive to us from the sun instantaneously, as was formerly supposed.

Obs.—When Jupiter is in that portion of his orbit which is *nearest* to the earth, the eclipses of his satellites are seen about eight minutes sooner than they are when Jupiter is in that portion of his orbit which is *farthest*

from the earth; so that light moves 190 millions of miles (the diameter of the earth's orbit) in 16 minutes, or about 12 millions of miles in a minute.

164. Another advantage derived by the eclipses of the satellites of Jupiter, is the determination of the longitude of any place on the earth, where such eclipses are observed.

Obs.—If two persons at different places on the earth, observe the eclipsing of any particular satellite, the difference in the time of observation, reduced into degrees, by reckoning 15° for one hour, gives the difference of longitude of those places.

SATURN, AND HIS SEVEN SATELLITES.

(Plate VI. Fig. 2.)

165. Saturn was formerly considered the most distant planet in the solar system; he is expressed by this character ♄, denoting an old man supporting himself upon a staff. The same character is used to characterise lead among metals.

166. Saturn, to the naked eye, appears like a star of the second magnitude; it is 10,759 days, or nearly 30 years revolving round the sun, at a distance of 908 millions of miles from that luminary.

167. The diameter of Saturn is 77,950 miles; he has seven moons constantly attending him, and he is encircled by a luminous double ring, which appears to be distinct and at some distance from his body.

168. The surface of Saturn is likewise circumscribed with various belts, like those of

The Planet Jupiter, with his four Satellites, as seen through a Telescop

The Planet Saturn, with his seven Satellites, as seen through a Telescope

Jupiter, and spots, by which astronomers have found that he revolves on his axis in 10 hours 16 minutes.

169. The orbit of Saturn makes an angle of 2° 30' with the plane of the ecliptic. The place of his ascending node is 22° of ♋, and the place of his descending node is 22° of ♑.

170. The ring of Saturn is a broad circular arch, encompassing the body of the planet, without touching it, somewhat similar to the wooden horizon of an artificial globe. The ring was first discovered by Galileo in the year 1609.

171. Five of the Satellites of Saturn were discovered by Cassini and Huygens, and the last two, being the nearest to the planet, by the eminent Dr. Herschell with his majestic telescope, which magnifies not less than *six thousand times!*

172. The *ring* of Saturn appears to be composed of solid matter, because it has a motion on its axis, and casts a shadow on the surface of the planet.

HERSCHELL, WITH HIS SIX SATELLITES.

173. The Herschell planet was discovered by Dr. Herschell, at Bath, on March 13, 1781, near the foot of Castor; and, from its discoverer, has derived its name. The character by which it is distinguished is ♅.

174. The distance of Herschell from the sun, is 1813 millions of miles; and it requires 31,346 days, or nearly 86 years to revolve round the

sun. In appearance it is about the size of a star of the sixth or seventh magnitude.

175. The diameter of this planet is 34,404 miles; and, in its progress round the sun, it is attended by six satellites or moons.

176. This planet is by many astronomers called Uranus, because as Mars was the son of Jupiter, so Jupiter was the son of Saturn, and Saturn's father was named Uranus among the heathen deities.

Obs.—Herschell's ascending node is $2^s.\ 12°$, or $12°$ of ☊, and his descending node $8^s.\ 12°$, or $12°$ of ♌; and his orbit is nearly parallel to the ecliptic, forming only an angle of 46′ therewith.

ASTEROIDS.

177. There are four smaller planets between the orbits of Mars and Jupiter, called Asteroids: they were so named by Dr. Herschell.

178. The asteroids are called Vesta, Juno, Ceres, and Pallas; they are about the size of our moon, and revolve round the sun in four years and eight months, at a distance of 288 millions of miles.

179. These asteroids are invisible to the naked eye; their theories are very little known.

OF THE FLUX AND REFLUX OF THE TIDES.

180. A tide is that motion in the seas or rivers, by which they rise and fall in regular succession.

181. This motion of rising and falling is occasioned by the mutual attractions of the sun and moon upon the water,

182. There are two tides in the space of 25 hours; or it is high water at any place once in about twelve hours and a half.

183. At the conjunction of the sun and moon, both these luminaries are on the same side of the earth, and by their united attractions upon the same portions of the water, conspire to elevate its surface more than at other times; so, when the sun and moon are in opposition, the sun by his influence raises the water on one side of the earth, at the same time that the moon elevates it on the opposite side.

184. The mean attraction of the moon in elevating the water, to that of the sun, is as five is to one, and the nearer these bodies are to the earth, the higher will be the tides.

Obs.—The lowest tides happen when the moon is in her quadratures, and the highest when she is in her syzygies, or about two or three days after. Lakes have no tides, because every portion of their surface is attracted alike.

COMETS.

(Plate IV. Fig. 1.)

185. There are other celestial bodies besides planets, which traverse infinite space, called Comets, and are known from the planets by their being attended with a luminous tail, in a direction opposite the sun.

186. Comets revolve round the sun in very eccentric orbits, in some part of which, they are frequently as near the sun as Mercury, and

at the opposite part, even farther distant than Herschell.

187. Comets were formerly considered as supernatural agents, sent by the incensed Deity as omens of plagues, pestilences, famines, and other scourges of mankind, for crimes committed against the Divine Being.

Obs.—"Their nature being now better understood, they are no longer terrible; but as there are many illiterate people who still think them warnings of portending evils to mankind, it may not be improper to remember that the great Architect of the universe has formed every part of his creation according to his own infinite wisdom, in divine and perfect order, and subjected all to laws and regulations He does not hurl worlds at random through infinite space, or permit any portion of his works to be affected by fortuitous circumstances. Religion glories in the test of reason, of knowledge, and of true wisdom; it is every where connected with, and elucidated by them. From philosophy we may learn, that the more the works of our benign Creator are contemplated, the more he must be adored; and his government and superintendence over every portion of his creation will be evinced."

188. Tycho Brahe, a Danish astronomer, was the first who restored comets to their true rank in the creation, by assigning them their situation in the solar system.

189. Sir Isaac Newton says, Comets are compact, solid, and durable bodies, moving in very oblique orbits, and their tails are a very thin and slender vapour, emitted by the head or nucleus of the comet, ignited or heated by the sun's rays. They are only visible to us when they are in that portion of their orbit nearest to the sun.

190. The periodical times of the greater number of the comets are uncertain. One is known to be 76 years, and another 575 years, performing their courses in their respective orbits.

191. The number of comets already observed is about five hundred; one of which appeared in the year 1680, Sir Isaac Newton imagined to have been, when nearest the sun, 2000 times hotter than red-hot iron, and that if it were so large as the earth, it would take at least 50,000 years to cool, and its tail was 80 millions of miles in length. The splendid comet of 1811, when nearest the earth, was 114 millions of miles distant. It was about the size of the earth, and was visible during three or four months. Its tail was 11 millions of miles long. The comet of 1819 had a very majestic appearance; it was not visible here until it had passed its perihelion. Its tail was at least 15 millions of miles in length.

OF THE FIXED STARS.

192. The universe, so far as human observation has extended, consists of infinite or boundless space, in which are numberless fixed stars, of the nature, bulk, and properties of the sun; but because they are at such immense distances from the earth, they appear to our eyes only as so many beautiful shining points.

193. The fixed stars are bodies shining by their innate effulgence; each is supposed to be the centre of a system, like our solar system, with primary and secondary planets, comets, &c. revolving respectively round it.

194. All the fixed stars excepting the polar star, appear to have a motion like the sun and moon, rising in the east; increasing in altitude until they approach the meridian, and declining to the western horizon, where they disappear.

195. The apparent motion of the stars from east to west, is occasioned by the revolution of the earth on its axis from west to east.

196. The polar star being near the north pole of the heavens, appears to be stationary; but this, if carefully observed, and other stars, whose north polar distance is less than the latitude, will appear to describe a circle round the pole, once in every sidereal day. These are called circumpolar stars.

197. The altitude of the pole above the horizon of any place, is always equal to the latitude of that place. Therefore, when the pole star has the same altitude as the pole, this altitude determines the latitude of the place of observation.

198. The stars appear innumerable on a clear winter's evening. This is occasioned partly by viewing them all at the same time, and partly by their incessant twinkling. Not more than five hundred can be individually numbered on any evening with the naked eye.

199. The distances of the fixed stars cannot be ascertained with any degree of *certainty*, because the diameter of the earth's annual orbit, which is 190 millions of miles, is a mere point when compared with their inconceivable distance.

Obs.—Various methods have been adopted by the

most eminent astronomers, to endeavour to ascertain the distances of the fixed stars, but all have hitherto failed in producing any satisfactory conclusion. The diameter of the earth's annual orbit, which is 190 millions of miles, does not form an angle of 2″ at the nearest fixed star.

200. The stars, when viewed through glasses of the greatest magnifying powers, appear the same size as without the telescope; while the planets are magnified in appearance, according to the power of the instrument with which they are viewed.

Obs.—The swiftest motion we know of, is light, which is about eight minutes coming from the sun to the earth, yet light would be a year and a quarter coming from Sirius, the nearest fixed star, to the earth. A cannon ball, which moves at the rate of 20 miles in a minute, would be 760,000 years in coming from Sirius to us, if it were to proceed with the same velocity as when first projected. Sound, which moves 1142 feet in a second, or about 13 miles in a minute, would be upwards of a million years reaching us from the nearest fixed star!

201. For the purpose of more readily noticing any particular star, astronomers have divided the stars into six sizes or magnitudes, each classed according to its brightness.

202. For the purpose of finding and referring to any particular star, the Babylonian astronomers first divided the stars into asterisms or constellations, such as bears, lions, dogs, the horse, the bull, the ram, &c. just as they fancied any particular cluster of stars to represent the predominant parts of any particular animal.

Obs.—But modern astronomers have, with greater precision, represented the stars in any particular constellation, by the letters of the Greek alphabet, accord-

ing to their brightness, and thus have superseded the necessity of having these animals depicted on the celestial globe.

203. The number of constellations is 93. There are 34 north of the zodiac, 12 zodiacal constellations, and 47 south of the zodiac.

204. There are 20 stars of the largest size, called stars of the first magnitude; 65 of the second; 205 of the third; 485 of the fourth; 648 of the fifth; and about 1500 of the sixth magnitude; being all that can be seen with the naked eye, from all sides of the earth, the others can only be seen with a telescope.

205. Some of the most conspicuous constellations, are, Orion, in which are Rigel and Betelgeux, stars of the first magnitude; Gemini, containing Castor and Pollux, nearly of the first magnitude; Taurus, in which is a small cluster of stars called the Pleiades; the largest star in Taurus is Aldebaran; Ursa Major, in the Northern hemisphere has seven principal stars of the second and third magnitudes, two of which are called the Pointers, because they are nearly in a line with, and are said to point to the Pole star: far to the south, is Argo Navis, having in it many brilliant stars, the most distinguished is Canopus, of the first magnitude.

Obs.—The best way to distinguish any particular star, or cluster of stars, is with a celestial globe, by Prob. 15; for by rectifying the globe for any particular day, hour, and place, the star we observe in the heavens, whose name we wish to know, is in the exact position, altitude, &c. as in the firmament, and by its situation with respect to other stars, may very easily be named.

206. The Milky Way, is a light gleam of im-

mensely distant and numerous stars extending from the northern to the southern side of the heavens, which stars are visible only by a telescope of great magnifying power.

207. The firmament appears when viewed through a good telescope, abounding with numberless stars, which are invisible to the naked eye, on account of their distance. In a small portion of the Milky Way, the celebrated astronomer Herschell *says*, he observed and counted 116,000 stars in a quarter of an hour.

A LIST OF THE CONSTELLATIONS.

Zodiacal Constellations.

Names of the Constellations.		No. of Stars.	Principal Stars.
Aries	The Ram	66	Arietis 2
Taurus	The Bull	141	Aldebaran The Pleiades The Hyades
Gemini	The Twins	85	Castor 1 Pollux 2
Cancer	The Crab	83	
Leo	The Lion	95	Regulus, or Lion's Heart
Virgo	The Virgin	110	Spica Virginis 1 Vendemiatrix 2
Libra	The Balance	51	
Scorpio	The Scorpion	44	Antares 1
Sagittarius	The Archer	69	
Capricornus	The Goat	51	
Aquarius	The Water bearer	108	Scheat 3
Pisces	The Fishes	113	

The Northern Constellations.

Names of the Constellations.		No. of Stars.	Principal Stars.
Ursa Minor	The Little Bear	24	Pole Star 2
Ursa Major	The Great Bear	87	Dubhe 2
Cassiopeia	Lady in her Chair	55	Schedar 3
Perseus	Perseus	59	Algenib 2
Auriga	The Wagoner	66	Capella 1
Boötes	The Bear Driver	54	Arcturus 1
Draco	The Dragon	80	Rastaben 3
Cepheus	- - - - -	35	Alderamin 3
Canes Venatici	The Greyhounds	25	
Cor Caroli	Charles' Crown	3	
Triangulum	The Triangle	16	
Triangulum Minus	The Lesser Triangle	5	
Musca	The Bee -	6	
Lynx	- - - - - - - - -	44	
Leo Minor	The Little Lion	24	
Coma Berenices	Berenice's Hair	40	
Camelopardalus	The Camelopard	58	
Mons Menelaus	- - - - -	11	
Corona Borealis	The Northern Crown	21	
Serpens	The Serpent	50	
Scutum Sobieski	The Shield of Sobieski	8	
Hercules cum Ramo et Carbo	Hercules kneeling	113	Ras Algethi 3
Serpentarius sive Ophiuchus	Serpent	68	Ras Alhagus 3
Taurus Poniatowski	- - - - -	7	

Fig. 1.

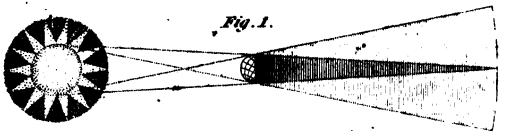


Fig. 2.

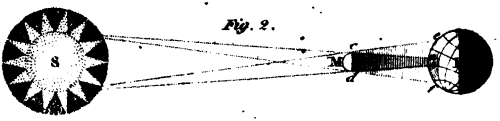


Fig. 3.

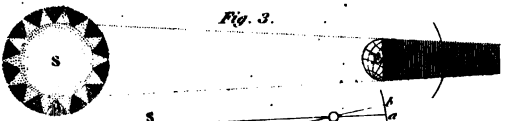


Fig. 4.

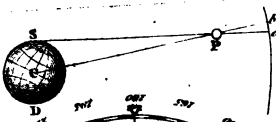
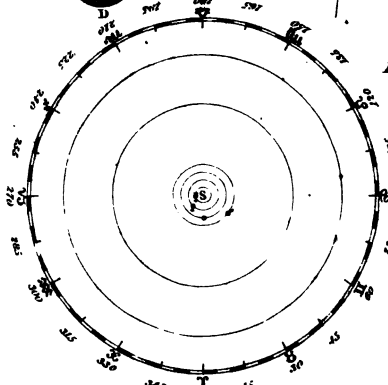


Fig. 5.



ECLIPSES OF THE SUN.

211. An eclipse of the sun is occasioned by the earth's passing through the shadow of the moon, when the rays of the sun are intercepted by the moon's body, and so prevented from reaching the earth.

212. As the moon must be in a line between the earth and the sun, to intercept his rays from us, eclipses of the sun must always happen at the time of new moon, or when the moon is in conjunction with the sun.

Obs.—This is a proof that the darkness recorded in the Scriptures, at the time of our Saviour's crucifixion was supernatural, and not caused by an eclipse of the sun; for the passover was always held at full moon, according to the Jewish law: it is therefore evident that she was not in a position to darken that luminary.

213. As the earth and sun are in the plane of the ecliptic, the moon's shadow must be in that plane either to eclipse the sun or to be eclipsed herself. The moon must, therefore, be in one of her nodes to eclipse the sun or to be eclipsed.

Obs. 1.—By knowing the place in the ecliptic of the moon's nodes, we may very readily ascertain when to expect a solar or lunar eclipse. The solar eclipse happening at the conjunction, and the lunar eclipse at the opposition, nearest to the moon's nodes.

2. The sun being a lucid body, he is not deprived of any of his light during the time we call a solar eclipse. The apparent dark portion of his surface is the moon's passing across his disc, or rather the earth's passing through the moon's shadow; and as the dark hemisphere of the moon is toward us, she is invisible. An eclipse of the sun is, properly speaking, an eclipse of the earth.

214. As the moon moves round the earth from west to east, the western side of the sun will be first eclipsed; then the centre, and the eastern side last.

Obs.—(Plate VII. Fig. 2.) Let S represent the sun, M the moon, and E the earth; *c a b d* a portion of the conical shadow of the moon: *a b* the portion thereof which touches the earth E; this portion of the moon's shadow is called the umbra, and this umbra never extends over a greater portion of the earth's surface than 180 miles; to all which portion of the earth the sun will be totally eclipsed, because the sun will be hidden entirely by the body of the moon. The portion of the shadow *c a e*, *d b f*, is called the penumbra, which may cover a space of 4900 miles, and the portions of the earth *a e*, *b f*, will see the sun partially eclipsed. Upon every portion of the earth where the penumbra does not fall, and where the sun is visible, he will not appear eclipsed at all.

215. An eclipse of the sun does not happen to all places at the same time, but appears earlier or later as the place is situated to the westward or the eastward; the motion of the moon being in that direction.

Eclipses of the Moon.

216. An eclipse of the moon is occasioned by her passing through the conical shadow of the earth, which shadow being dark, obscures her surface, and she is then deprived from receiving the light of the sun; just as if (vide Fig. 3. Plate VII.) S, E, and M, represent the sun, earth, and moon; M is eclipsed when passing through the shadow of E.

Obs.—An eclipse of the moon with us is an eclipse of the sun to the inhabitants of the moon; because the por-

tion of the moon which appears dark to us during an eclipse, is actually deprived of the light of the sun by the interposition of the earth; therefore the inhabitants of the eclipsed portion of the moon are prevented from seeing a portion of the sun; he therefore appears eclipsed to them.

217. An eclipse of the moon must happen when she is in opposition to the sun, that is, always at a full moon, which full moon happens nearest to the time that she is in her nodes.

218. As the moon is actually deprived of the rays of the sun, during the time she is eclipsed, that eclipse is visible to every inhabitant of the earth who beholds the moon.

219. The duration of an eclipse of the moon cannot exceed five hours and a half; and she cannot be totally eclipsed for a longer period than one hour and three quarters.

220. If the moon moved in the plane of the ecliptic, there would be an eclipse of the sun at every conjunction, and an eclipse of the moon at every opposition of these bodies.

Obs.—The nearest distance of the moon to the plane of the ecliptic is called her latitude; and if her latitude at her opposition be greater than the sum of the semi-diameters of the moon and sun, she cannot be eclipsed; but if her latitude be less than the sum of their semi-diameters, there will be a lunar eclipse. To illustrate this, (Plate VIII. Fig. 1.) Let GE be a portion of the ecliptic, or orbit of the earth, and HF a portion of the moon's orbit; V the place of the moon's node. If the moon be at V, when she is in opposition, she will be totally eclipsed; if at M, much eclipsed; when at O, less; and when at P, not at all; that is, when the sum of the semi-diameters of the sun and moon is equal to, or greater than the moon's latitude, which is, when the moon is about 17° from her node; this distance is called the lunar

ecliptic limit; and when she is within 12° of her node, at the time of conjunction there will be a solar eclipse. This is the solar ecliptic limit; and, consequently, the eclipses of the sun to the moon will be as 12: 17, or nearly as 2 to 3.

221. When the centres of the earth, the sun, and moon, are in an imaginary right line, the eclipse is called central; when the whole disc of either of the celestial bodies is obscured, the eclipse is called total; when a part of either luminary is obscured, the eclipse is called partial; and when, in solar eclipses, the moon appears in the middle of the sun, and the sun seems to form a ring round the moon, the eclipse is called annular.

222. Eclipses of the sun are more frequent than those of the moon; and yet there are, to any particular place, more *visible* eclipses of the moon than of the sun; because every eclipse of the moon is visible where she is visible, but an eclipse of the sun is only visible to a small portion of the earth even when the sun is visible.

223. The greatest number of eclipses than can happen in a year are seven, and the least number two; and these two must be both of the sun; the general number is four; two of each luminary.

224. The diameters of the sun and moon are supposed to be divided into twelve parts, called digits, and as many of these parts as are obscured in an eclipse, so many digits the body is said to be eclipsed.

Obs. 1.—A solar eclipse may be partial, central, total, and annular, at different places on the earth at the same time.

2. The lunar eclipses, by appearing to all places on the earth at the same time, are very useful in determining the difference of longitudes of places. If the eclipse be observed at two places with great exactness, by a well regulated time-piece, the difference in the times of observation, reduced into degrees, by allowing 15° to an hour, will give the difference of longitude of those places.

225. The moon's nodes are not always in the same sign and degree of the ecliptic, but have a retrograde motion of about 19° every year, which causes eclipses to happen irregularly, as they depend on the motion of the moon's nodes.

Obs. 1.—The exact time which the moon's nodes take to revolve from any particular part of the ecliptic to their being there again, is 18 ys. 11 ds. 7 hs. 43 min. 20 sec. when there are only four leap-years in these 18 years; but when there are five leap-years in these 18 years, then the exact period is 18 ys. 10 d. 7 hs. 43 min. 20 sec. This period is called the *Chaldean Saros.*

2. This affords us at once a very sure and easy method of calculating eclipses for any future period; for, by noticing from any table of conjunctions, or from any almanac, the exact time of conjunction of the sun and moon, by adding the Chaldean saros to that time, we have the period when the same eclipse will return again.

TABLE OF ECLIPSES.

Years.			Months and Days.	Time.	Years.			Months and Days.	Time.
1826	☾	T	Nov. 14	4½ A	1840	☉		March 4	4 M
——	☉		Nov. 29	11½ M	——	☾	P	Aug. 13	7½ M
1827	☉		April 26	3½ M	1841	☾	T	Feb. 6	2½ M
——	☾	P	May 11	8¾ M	——	☉		Feb. 21	11 M
——	☾	P	Nov. 3	5 A	——	☉		July 18	2 A
1828	☉		April 14	9¾ M	——	☾	T	Aug. 2	10 M
——	☉		Oct. 9	0½ M	1842	☾	P	Jan. 26	6 A
1829	☾	P	March 20	2 A	——	☉		July 8	7 M
——	☾	P	Sept. 13	7 M	——	☾	P	July 22	11 M
——	☉		Sept. 28	2½ M	1843	☾	P	June 12	8 M
1830	☉		Feb. 23	5 M	——	☾	P	Dec. 7	0½ M
——	☾	T	March 9	2 A	——	☉		Dec. 21	5½ M
——	☾	T	Sept. 2	11 A	1844	☾	T	May 31	11½ A
1831	☾	P	Feb. 26	5 A	——	☾	T	Nov. 25	0½ M
——	☾	P	Aug. 23	10½ M	1845	☉		May 6	10½ M
1832	☉		July 27	2½ A	——	☾	T	May 21	4½ A
1833	☾	P	Jan. 6	8 M	——	☾	P	Nov. 14	1 M
——	☾	P	July 2	1 M	1846	☉		April 25	5½ A
——	☉		July 17	7 M	——	☉		Oct. 20	8½ M
——	☾	T	Dec. 26	10 A	1847	☾	P	March 31	9½ A
1834	☾	T	June 21	8½ M	——	☉		Sept. 24	3 A
——	☾	P	Dec. 16	5½ M	——	☉		Oct. 9	9½ M
1835	☉		May 27	1½ A	1848	☾	T	March 19	9½ A
——	☾	P	June 10	11 A	——	☾	T	Sept. 13	6½ M
——	☉		Nov. 20	11 M	——	☉		Sept. 27	10 M
1836	☾	P	May 1	8½ M	1849	☉		Feb. 23	1½ M
——	☉		May 15	2½ A	——	☾	P	March 9	1 M
——	☾	P	Oct. 24	1½ A	——	☾	P	Sept. 2	5½ A
1837	☾	T	April 20	9 A	1850	☉		Feb. 12	6½ M
——	☉		May 4	7½ A	——	☉		Aug. 7	10 A
——	☾	T	Oct. 13	11½ A	1851	☾	P	Jan. 17	5 A
1838	☾	P	April 10	2¼ M	——	☾	P	July 13	7½ M
——	☾	P	Oct. 3	3 A	——	☉		July 28	2½ A
1839	☉		March 15	2½ A	1852	☾	T	Jan. 7	6½ M
——	☉		Sept. 7	10½ A	——	☾	T	July 1	3¾ A
1840	☾	P	Feb. 17	2 A	——	☉		Dec. 11	4 M

OF THE ASPECTS OF THE PLANETS.

226. The aspects of the planets contributed in the early ages of astronomy, to form the true or Copernican system, upon the ruins of the false systems which astronomers first invented.

227. The aspects of the planets are five, viz. conjunction, marked thus ☌; opposition, thus ☍; quartile, thus □; sextile, thus ⚹; and trine, thus △. The ascending node of a planet is marked ☊, and the descending node ☋.

228. When two planets, or any two celestial bodies are in the same portion of the zodiac as seen from the earth, that is, when their geocentric longitudes are the same, they are in conjunction.

229. Conjunctions are of two sorts, inferior and superior.

230. An inferior conjunction is when an inferior planet is directly between the earth and the sun; and a superior conjunction is when the sun is between the earth and the planet.

231. When any planet or celestial body is in opposition to the sun, such planet is in the same sign and degree in the ecliptic as the earth is, and is on the meridian at midnight, or twelve o'clock at night.

Obs. 1.—The earth's place in the ecliptic is always six signs, or 180° distant from the sun's place; and any planet being in opposition to the sun, has its place 180° or six signs from the sun's place.

2. The diagram (Plate VIII. Fig. 2.) will very readily illustrate the inferior and superior conjunctions of the inferior planets, with the conjunctions and oppositions of the superior.

Let V V′ V″ represent the orbit of an inferior planet, as Venus; E E′ E″ the orbit of the Earth, M M′ M″ the orbit of any superior planet, as Mars; let S represent the sun in the centre. Now Venus, the Earth, and Mars all appear, when at V, E, and M, in the same position of the zodiac when viewed from the sun; namely, in ♎; their heliocentric places are the same; but Venus, when at V, appears to a spectator on E to be in ♈: this position of Venus is denominated her inferior conjunction, she being then immediately between S, the Sun, and E, the Earth; and the point of the ecliptic, ♈ is her geocentric place; consequently her geocentric place is six signs distant from her real or heliocentric place. When Venus is at V″, she is then in her superior conjunction. It is evident that the planet Venus is never visible to us at her inferior or superior conjunction. She, at her inferior conjunction, will sometimes appear to cross the sun's disc, and is then seen like a spot on his surface. This transit may continue five hours. The planet Mars, when at M, is in the same point of the ecliptic as the earth is, and is then in opposition to the sun. He comes to the meridian then at midnight.

232. The inferior planets have an inferior and a superior conjunction, but no opposition; and the superior planets have an opposition and a conjunction, but no inferior conjunction. Any planet being in opposition to the sun, is in the same sign as the earth is, or six signs from the sun's place.

Obs.—By considering that no inferior planet can be seen in the middle of the night, we have an infallible criterion to tell at first sight the name of any planet we may observe in the evening. If it be of a red fiery appearance, it is Mars; if of a lustre far surpassing even the brilliancy of Sirius, it is Jupiter; but if it be noticed as a star of the second magnitude, moving very tardily around the centre of the system, it is Saturn, the most distant of the planets observable to the naked eye.

233. When any planet has a quartile aspect with respect to another celestial body, its geocentric place is then three signs, or 90° from the geocentric place of that celestial body.

234. When any planet has a sextile aspect with respcet to another celestial body, its geocentric place is two signs, or 60° distant from that celestial body.

235. When one heavenly body has a trine aspect with regard to another celestial body, their geocentric places are 4 signs distant, that is, 120°.

236. These aspects of the planets, and of the other celestial bodies, *were* considered of very great moment in astrological calculations. The planets situated according to any of these aspects, being *imagined* by astrologers to have various influences on the destinies of mankind.

Of the real and apparent Motions of the Planets, and the Determination of the distances of the inferior Planets.

237. All the planets move in one direction round the sun, as a centre, going through the twelve signs of the zodiac, in grand majestic succession, from west to east.

238. This revolution of the planets, from Aries, through Taurus, Gemini, &c. is their real, generally called their direct, motion: and whatever sign of the zodiac they may be in, as seen from the sun, is their real place.

239. The apparent place of any celestial body, is its situation in the zodiac, as seen from the earth, so that heliocentric is synonymous to real; and geocentric, to apparent.

240. The planets frequently appear to us to move backwards, or contrary to the order of the signs; this backward motion is called their retrograde motion, or motion antecedentia.

241. The retrograde motion of an inferior planet is occasioned by its motion through the zodiac being quicker than the motion of the earth in the ecliptic; and the retrograde motion of a superior planet is occasioned by the earth's motion being quicker than the motion of such superior planet in its orbit; the stationary appearance of a planet is occasioned by such planet having a quicker or slower motion in its orbit, than the earth has in the ecliptic.

Obs. 1.—(Plate VIII. Fig. 8.) Let E represent the earth, V the position of the planet Venus, when in her inferior conjunction V^1, V^2, V^3, V^4, and V^5, various positions of the planet while revolving around S. When Venus is at V, her inferior, and V^3, her superior conjunction, she will appear to a spectator at E to be in ♈; when she is in that part of her orbit represented by V^5, she will appear at *d*, and when she is at V^1 at *a*. When Venus is moving from V^5 to V^1, she will, to a person stationed at E, appear to describe the arc *d c* ♈ ♓ *a*; and, while moving from V^1 to V^5, she will appear to recede, and describe the arc *a b* ♈ ♉ *d*. This is called her direct, and that her retrograde motion. When she is at V^1, or V^5, she will appear to remain at *a* and *d* some time. This is called her stationary appearance. But by reason of the planets' proximity to the sun, she is invisible to the eye of a spectator at E, excepting at V^1 or V^3, when she appears westward of the sun, and illuminates our horizon just before the sun has begun his daily course, and she is then denominated the Morning Star; or, when she is at V^4 or V^5, and is eastward of the sun, she then rises after the sun, and sets after him. She then adorns the western sky in the evening, and is denominated the Evening Star.

Fig. 1.

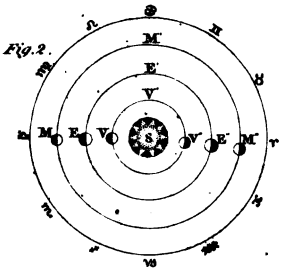


Fig. 2.

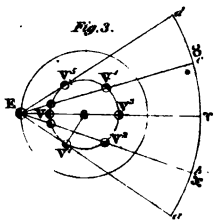


Fig. 3.

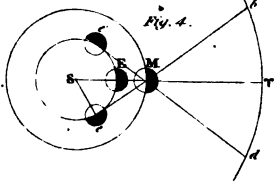


Fig. 4.

2. By noticing the same figure, we observe that the inferior planets never are very distant from the sun's place. The distance of an inferior planet's geocentric place and the sun's place, is the planet's elongation, equal to the angle formed at the earth by imaginary lines from the sun and planet, equal to the angle ☿ E ☉. This is called the planet's *greatest* elongation. This, in the planet Venus, is 48°.

3. From the greatest elongation of an inferior planet, we derive an easy method of finding its distance from the sun. For, let V^I and S be joined, then in the right angled triangle EV^IS right angled at V^I, we have ES = 95 millions of miles, and the $\angle V^I ES = 48°$, to find $V^I S$: that is, as Rad = S $\angle V^I$: E S = 95 :: S $\angle$ E = 48° : V^I S = the planet's distance from the sun.

Of the direct and retrograde motion of the Superior Planets, the Determination of their Distances, &c.

Let S (Plate VIII. Fig. 4.) represent the sun, *e*E*e'* the orbit of the earth, M any position of either of the superior planets, as Mars. Now let us imagine the planet M to be stationary, while the earth moves through the arc *e*E*e'*. The planet M, to a spectator at E, appears at ☿; at *e'*, M appears at *a*; and at *e*, M appears at *b*. When the earth is moving through the arc *e*E*e'*, the planet will appear to go through the arc *b*☿*a*, or to move retrograde. When the earth is at *e'*, the planet will appear stationary; and when the earth is moving from *e'*, onward in her orbit, the planet's motion will be direct.

This diagram affords us an easy method of finding the distance of any superior planet; for by joining *e*S, in the right angled triangle M *e* S, we have *e*S = 95 millions of miles; and the ob-

served $\angle e$MS, to find SM, the planet's mean distance from the sun: or the same distance may be found with the planet's horizontal parallax.

242. The retrograde motion of an inferior planet happens when that planet is at its greatest elongation, and the retrograde motion of a superior planet, just before its opposition to the sun.

ON PARALLAX.

243. The parallax of any celestial body is the angle the semi-diameter of the earth forms at that body.

(Plate VII. Fig. 4.) Let SCD represent the diameter of the earth, C its centre, P any celestial body viewed by a spectator at S; then is the angle SPC, the parallax of the body P, equal to the angle bPa, equal to the angle the radius SC of the earth forms at the body P.

244. The place in which any celestial body would appear, to a spectator at the earth's centre, is called its true place; and the place where it actually does appear, its apparent place.

Obs.—The parallax of any celestial body added to its apparent place will give its true place.

245. The parallax of any body, when in the horizon, is called its horizontal parallax.

Obs.—By knowing the horizontal parallax of any celestial body, we can very readily find its distance from us by plain trigonometry.

246. The angle which the sun and earth form at any planet or star, is called the parallax of the earth's annual orbit.

Obs.—The farther distant any celestial body is from us, the less will be its parallax. Thus the parallax of the Moon is 57′ 49″; of Mars 23.6″; of the Sun 8.8″; and the fixed stars are so distant that they have scarcely any parallax with the earth's annual orbit.

ABSTRACT OF ASTRONOMY.

The solar system comprises the sun, and all bodies which revolve round him as a centre. These are planets, comets, and asteroids.

The number of comets is unknown. About five hundred have already been observed.

There are seven primary planets, and eighteen secondary planets.

The figure of the earth is not that of a perfect globe, the equatorial diameter being a little longer than the polar.

The planets Jupiter and Saturn are also observed to be flattened at the poles, but in a greater proportion than the earth. This is caused by the revolutions of those planets on their axes, and these axes being inclined always in one direction.

The orbits of all the planets, asteroids, comets, and satellites, are elliptical, having the sun or planet round which they revolve in one of the foci of the elliptic curve.

The periods, distances, and magnitudes of the planets have all been determined with very considerable exactness, but the orbits of the comets, being so very eccentric, these bodies only appearing when in their perihelion, or near-

est distance to the sun, their theories are consequently merely hypothetical.

The planets, comets, and satellites are preserved in their orbits by the power of gravitation. This was first proved by Sir Isaac Newton.

All the planets revolve about an imaginary line within themselves, called their axis. The time in which a planet revolves round its axis is called its day. The time a planet takes to revolve round the sun forms its year.

The different lengths of the day and night are occasioned by the inclination of the axis of the earth.

The different seasons are occasioned by the different lengths of day and night.

Jupiter is the largest planet in the solar system; and yet it takes the least time to revolve on its axis.

Mercury is the least planet in the solar system; and yet it takes nearly the longest period to revolve on its axis.

The moon's year consists only of twelve days and one sixth nearly, and each of her days is 29½ of our days in length.

The moon is the only body we know of which revolves on its axis from east to west; all other bodies revolving from west to east.

The fixed stars are distinguished from the planets by their twinkling, and by their being always in one position with respect to each other.

The stars have no sensible magnitude, even through the best telescopes, while the planets are increased in apparent magnitude, according to the magnifying powers of the instrument.

The naked eye cannot discover more than five hundred stars on any clear evening; yet the firmament is supposed to contain eight millions.

Every star is supposed to be a sun, having planets, comets, &c. revolving round it.

An eclipse of the moon is occasioned by her passing through the conical shadow of the earth.

An eclipse of the sun is occasioned by the earth's being in the conical shadow of the moon.

Motion is the measure of time; and the motion of the heavenly bodies is the basis by which all other motions are compared.

The day is the first and grand division of time; all other portions being founded on this.

THE ELEMENTS OF ASTRONOMY.

PART II.

PLANETARY PROBLEMS.

The following problems are founded upon the hypothesis, that the planets revolve round the sun in circular orbits, which though not mathematically correct, as has been proved in a preceding part of the work, is sufficiently so, to enable the young student to determine the solution of any question found herein with a correctness sufficiently exact for practical purposes. The demonstrations and the investigations of the following rules have been purposely omitted, as their introduction would have been foreign to the design of the present work. The teacher is particularly recommended to enforce the study of the subsequent problems, as they afford a test of aritmetical knowledge, and have a tendency to mature the judgment and to ripen the understanding of the student, for the further prosecution of astronomical investigations.

PROBLEM I.

To convert time into Degrees, Minutes, &c. &c.

RULE.—Reduce the minutes, seconds, &c. into decimal parts of an hour; then say, as 1 hour : 15° :: the time given : the degrees required.

As 1 hr. : 15° . : $3\frac{1}{2}$ hrs. : $52\frac{1}{2}°$ = 52 30′.

2. How many degrees, &c. are equal to 4 hrs. 16 min.?

3. How many degrees, &c. are equal to 5hrs. 11′ 20″?

4. In 11hrs. 28′ 18″, how many degrees?

5. An eclipse of the moon was observed to commence at Greenwich at 11hrs. 58′ 53″, and at New-York at 7hrs. 2′ 50″, what is the difference of longitude of these two places?

6. How many degrees is the Sun distant from the meridian at 4hrs. 17′ A. M.?

7. How many degrees is the Sun distant from the meridian, at 10hrs. 17′ A. M.?

8. If Saturn be in 7° of ♈, in what degree of the ecliptic is Jupiter's longitude when this is on the meridian 2hrs. 18′ 19″ after that?*

9. Saturn was observed to appear on the meridian, 40 minutes after Jupiter, how far were these planets asunder?

10. What is the difference of longitude of two places, to one of which the Sun appears on the meridian, 1hr. 19′ before he appears on the meridian of the other?

11. Two stars are observed to come on the meridian within 2hrs. 49′ 17″ of each other, what is their difference of longitude?

12. If Venus be observed to rise $1\frac{3}{4}$hr. before the Sun, what is her elongation at that time?

* In questions 8th, 9th, 11th, 12th, 13th, 14th, and 15th, of Problem I. the difference of time, reduced to degrees, will be the difference of right ascension; the right ascension of each planet being found, their longitudes may thence be obtained. *Ed.*

13. If Jupiter set 3hrs. 19′ after the Sun, what is their difference of longitude?

14. On November 21, 1823, Saturn rises at 6hrs. 25′ in the morning, and the Sun at 7hrs. 0′, what is their difference of longitude?

15. On August 1, 1823, Venus sets at 9hrs. 3′, in the evening, and the Sun at 7hrs, 8′, what is the elongation of Venus on that day?

PROBLEM II.

To Convert Degrees, Minutes, &c. into Time.

RULE.—Reduce the minutes, &c. into decimal parts of a degree; and then say as 15° : 1hr. : : the degrees given : the time required.

EXAMPLES.

16. What is the time answering to 84°?

Solution.—As 15° : 1 hr. : : 84° : 5 hrs.—36′, the time required.

17. What is the time answering to 78° 16′?

18. What is the time answering to 81° 17′?

19. What is the time answering to 123° 18′?

20. What is the time answering to 180°?

21. The difference of longitude of two places is 78° 10′; what is their difference in time?

22. The longitude of New-York is about 3° east of Washington; when it is 12 o'clock at Washington, what is the time at New-York?

23. The longitude of Amsterdam is 10° 25′ E. When it is 12 o'clock at Amsterdam, what is the time at London?

24. Dumfries is in 3° 23′ W.; Kingston in 76° 37′ W. What is their difference of time; and when it is 7 o'clock at Dumfries, what is the time at Kingston?

25. In an eclipse of the moon, the beginning will be at 8hrs. 18' at Philadelphia: when may it be expected at Boston, New-Haven, New-York, Charleston, S. C. Washington, and St. Louis?

26. If the greatest elongation of Mercury be 28° 20', how long can he rise before the Sun, when a morning star?*

27. If the greatest elongation of Venus be 48°; how long does she rise or set before the sun, when she is in that portion of her orbit?

28. October 1, 1823. At this time Venus is in Libra, 22° 2'; Mars in Leo, 15° 33'; Jupiter in Cancer, 9° 48'. What time elapses between these planets coming to the meridian?

29. The difference of longitude of two stars is 73° 19': how long will one be on the meridian before the other?

30. The difference of longitude of Jupiter and Mars on a certain day, is 3 signs 7° 18': what time elapses between these planets coming to any meridian?

31. The longitude of Venus 43° 17'; and of Mars 93° 10'; how many hours elapse between these planets passing the meridian?

PROBLEM III.

Having the Diurnal arc of the Sun, or of any Planet given, to find at what Hour the Sun rises and sets.

RULE.—Bring the diurnal arc into time, by the last problem; divide the time thus found by

* From Question 26th to 31st inclusive, the longitudes should be changed to right ascension, to obtain the true difference of time. *Ed.*

2, and it will give the time the Sun sets; if this time be taken from 12 hours, it will leave the time the Sun rises.

EXAMPLES.

32. The Sun's diurnal arc is 176°: at what hour does he rise and set?

Solution.—As 15° : 1hr. : : 176° : 11hrs. 44′.

Then $\frac{11\text{hrs. } 44'}{2} = 5\text{ hrs. } 52' =$ time the Sun sets, and 12h.—5 hrs. 52′ = 6 hrs. 8′ = the time he rises.

33. The Sun's diurnal arc is 217° on a certain day; at what hour does he rise and set?

34. The Sun's diurnal arc is 170° 18′; at what hour does he rise and set?

35. The Sun's diurnal arc is 151° 17′; at what hour does he rise and set?

36. The Sun's diurnal arc is 73° 12′; at what hour does he rise and set?

37. The diurnal arc of Venus is 94° 17′; what is her diurnal arc in time?

38. The diurnal arc of Mars is 196° 18′; how many hours will elapse from the time of this planet's rising, till it comes to the meridian?

39. The diurnal arc of Jupiter is 213° 17′; what is this planet's semi-diurnal arc in time?

40. The diurnal arc of Saturn is 200° 12′; how many hours elapse from his rising to his setting?

41. When Venus rises at 5 o'clock, A.M. how many hours is she above the horizon?

PROBLEM IV.

By having the number of hours the Sun, or any Planet is above the horizon, to find the Length of its diurnal or nocturnal arc in degrees.

RULE.—Divide the number of hours the Sun or planet is above the horizon by 2, and it will give the time the sun sets; and if this be taken from 12 hrs. it will leave the time the sun rises.

The number of hours the sun is above the horizon, multiplied hy 15°, will give the length of the sun or planet's diurnal arc.

EXAMPLES.

42. When the Sun continues above the horizon 12 hours, at what hour does he rise and set, and what is the length of his diurnal arc?

Solution. $\frac{12}{2}$ = 6 hrs. = time the Sun rises and sets, and $12 \times 15° = 180°$ = the length of his diurnal arc.

43. When the Sun continues above the horizon 13hrs. 17', at what hour does he rise and set, and what is the length of his nocturnal arc?

44. When Saturn continues 15hrs. above the horizon, what is the length of his nocturnal arc?

45. When Jupiter continues 17 hrs. 19' 24" above the horizon, what is this planet's nocturnal arc?

46. When Mars continues 20hrs. 16' 7" above the horizon, what is his semi-diurnal arc?

47. When Venus continues 13 hours 14′ 16″ above the horizon, what is the length of her diurnal arc?

48. On April 16, the sun rose at 5 hrs. 17′; how many hours from sun-rise to sun-set, and what is the length of his nocturnal arc?

49. On June 21, the sun rose at 3 hrs. 47′; how many hours from sun-rise to sun-set, and what is the length of his diurnal arc?

PROBLEM V.

To determine the number of days which elapse between two Conjunctions or two Oppositions; or between a Conjunction and an Opposition, of any two planets.

Rules. 1.—Find the difference of their daily motions, from the table on page 91.

2. For two conjunctions, or two oppositions, say, as the difference of their daily motions : 1 day : : 360° : to the difference in the times of two conjunctions required.

3. For a conjunction and an opposition, or for an inferior and superior conjunction, say, as the difference of their daily motions : 1 day : : 180° : to the time elapsing between a conjunction and an opposition of the two given planets.

Planets.	Planets' Daily motion.	Heli. Long. Jan. 1. 1823.
Mercury	4.0928°	277° 25′
Venus	1.6021	285 16
Earth	.9856	100 20
Mars	.5240	311 41
Jupiter	.0831	64 51
Saturn	.0335	38 56
Herschell	.0118	277 30
Sun's Geo. Longitude, Jan. 1.		280° 21′

EXAMPLES.

50. How many days elapse between two conjunctions of Mercury and Venus?

Mercury's daily motion - 4.0928
Venus's do do. - 1.6021

Difference 2.4907. Then,

As 2.4907 : 1 : : 360° : 144 days, the time required.

51. How many days elapse between a conjunction and an opposition of Venus and Mercury?

52. How many days elapse between two conjunctions of Jupiter and Saturn?

53. How many days is Venus a morning and an evening star alternately to us?

54. How many days is the Earth a morning and an evening star alternately to the inhabitants of the planet Mars?

55. How many days is Mars a morning and an evening star to Jupiter?

56. How many days is Saturn a morning and an evening star to Herschell?

57. How many days elapse between two oppositions of Saturn and Mars?

58. How many days is Mercury east and west of the sun alternately to us?

59. How many conjunctions have the Earth and Venus in the period that Saturn and Herschell have two?

60. How many days is Jupiter a morning and an evening star alternately to us?

PROBLEM VI.

Having the Heliocentric Longitude of any two Planets given for any particular day, to determine when they will be in Heliocentric conjunction.

RULE.—If the longitude of the planet which is farthest from the sun, be *less* than the longitude of the planet which is nearest, increase it by 360°, and subtract the longitude of the nearer from the longitude of the farther planet. Then say, as the difference of their daily motions (taken from the table, page 91) : 1 day : : the

difference of the longitudes last found : days reckoning from January 1, when such given planets will be in conjunction.

EXAMPLES.

61. How many days will elapse after Jan. 1, 1823, before Venus and Mars will be in conjunction?

Solution.

Daily motion of Venus	1.6021
Daily motion of Mars	.5240
Difference - -	1.0781
Long of Mars - -	311° 41′
Ditto of Venus - -	285° 16′
Difference - -	26° 25′

As 1.0781 : 1 day : : 26° 25′ : 24 days after Jan. 1, answering to Jan. 25, when these planets will be in conjunction.

62. On what day in the year 1824, will Jupiter and Mars be in ☌?

63. On what day in the year 1824, will Jupiter and Saturn be in ☌?

64. On what day in the year 1824, will Venus and Saturn be in ☌?

65 On what day will Herschell be in ☌ with the Earth in the year 1824?

66. When will Venus and Jupiter be in ☌ in the year 1824?

67. When, in the year 1827, will Mars be on the meridian at midnight?

68. On what day of the year 1824, may I expect to see Saturn setting and the Sun rising at the same time?

69. How many days will elapse after Jan. 1, 1824, before Mars will set at sun-rising?

70. In the year 1824, when will Jupiter set at sun-rising?

71. In the year 1825 in what month will Jupiter be on the meridian of Washington at midnight?

PROBLEM VII.

Having a Planet's Heliocentric Longitude for any given day given, to find its Heliocentric Longitude for any other day.

RULES.—1. Find the number of days between the given day and the day required.

2 Then, as 1 day : the planet's daily motion : : the number of days from the given to the required day : the space the planet has revolved in its orbit in that time. This distance, added to the planet's longitude on the given day, will be the longitude of the planet required. If this sum be greater than 360° divide it by 360, so shall the remainder be the planet's longitude required.

EXAMPLES.

72. What is the longitude of Venus, May 25, 1824? on Jan. 1. it was 150° 2'.

Solution. From Jan. 1 to May 25, are 145 days. Then as 1 day : 1.6021 : : 145 : 232° 18'.

And 150° 2'+232° 18'=382° 20'. Then 382° 20'—360°=22° 20', the longitude required.

73. On January 1, 1824, the longitude of Saturn is 52° 11', what will its longitude be August 22, of the same year?

74. On Jan. 1, 1824, the longitude of Jupiter is 96° 22', what will it be April 24, 1826?

75. What will be the longitude of Mercury, June 18, 1825?

76. What will be the longitude of the Earth April 27, 1829?

77. What is the Sun's place Nov 9, 1825?

78. What is the longitude of Mars Nov, 19, 1827?

79. What is the longitude of Jupiter Nov. 16, 1825?

80. In what sign of the zodiac must I look for the planet Herschell, October 16, 1829?

PROBLEM VIII.

To determine, on any particular day, whether Jupiter or Venus be the Morning or the Evening Star.

RULE. Find the longitude of Venus or Jupiter, and the longitude of the Earth for the given day. Then if the difference of the longitude of the given planet and the Earth, (counting from the Earth's place onward,) be less than 180°, the planet rises after the Sun and sets after him; and is consequently an evening star; but if the said difference be greater than 180°, the planet rises before the Sun, and is consequently a morning star.

EXAMPLES.

81. On May 25, 1824, is Venus a morning or an evening star?

Solution. The longitude of the earth on May 25, is, by the last problem 244° 9', and the longitude of Venus 22° 28'. Then 244° 9'—22° 28' =221° 41', this being more than 180° shows that Venus is a morning star.

82. Is Jupiter a morning or an evening star, August 8, 1826?

83. Is Venus a morning or evening star, December 11, 1827?

84. Is Venus a morning or evening star on the following days?

Jan. 1, 1823.	Dec. 6, 1824.
Oct. 7, 1825.	Nov. 7, 1824.
July 16, 1826.	April 11, 1823.
Nov. 9, 1830.	Oct. 7, 1830.

85. Does Jupiter rise before or after the sun on November 9, 1824?

86. Does Jupiter rise before or after the Sun on May 17, 1823?

87. Is Venus a morning or evening star July 18, 1830?

88 During the month of Octabor 1827, is Jupiter or Venus the morning star?

PROBLEM IX.

To find on what Day any particular Planet shall have any given Longitude.

RULES.—1. Subtract the longitude of the planet on January 1, 1823, from the given lon-

gitude, taking care to increase the given longitude by 360° if the longitude on January 1, be greater than the given longitude.

2. Divide the degrees last found, (having previously reduced the minutes, &c. into decimal parts of a degree,) by the planet's tabular daily motion: the quotient will be the number of days from January 1, when the planet will have the given longitude.

EXAMPLES.

89. On what day of the year 1823, will the longitude of Venus be 173°?

Solution.

Given longitude of Venus 173°+360°=533°
Longitude on Jan. 1. 1823. =285° 16′

Difference =247° 44′=247.7.333

Then $\frac{247.7.333}{1.6021}$=154 days, answering to June 4th.

90. On what day of the year 1825 will Mars have no longitude?

91. When will Herschell be in 29° ♑?

92. When will ☿ be in ♈ 9°?

93. When will Venus be in ♓ 18°?

94. When will Saturn enter ♋?

95. When will Mars be in ♉ 9°?

96. When will the Earth enter ♌?

97. When will Mars be in 7° ♊?

98. On what day of the year 1828 will Jupiter be in the beginning of ♎?

99. The ascending node of Mercury is 1°. 16° 4′; when will the planet pass its node in the year 1824?

100. The descending node of Venus is 8ˢ. 14° 67′; when will she pass that node in the year 1824?

101. The descending node of Mercury is ♏ 16° 4′; when will it pass that node in the year 1824?

102. The ☊, or ascending node of Mars is ♉ 18° 6′; when will Mars be in his node in the year 1825?

103. When will Jupiter next pass his ascending node, after the beginning of 1824?

104. When will Saturn next pass his ascending node, after the beginning of 1824?

PROBLEM. X.

To find whether either of the Inferior Planets can transit the Sun in any particular year.

RULE.—Find (by the last problem) on what day the said planet will pass its nodes. Then find the Earth's longitude for that day, and if it be equal to the planet's longitude, or, which is the same thing, equal to the longitude of the planet's node, the planet will appear to transit the Sun; but if the longitude of the Earth be greater or less than the longitude of the planet, it will not transit the Sun.

EXAMPLES.

105. Will Venus transit the Sun in the year 1824?

Solution.—The longitude of the ascending node of Venus is 75° 8′, and by the last problem, she will pass that node on June 26, when

the Earth's longitude is 274° 44', consequently there will be no transit then. The longitude of the descending node is 255° 8', which node she passes March 5, when the Earth's longitude is 164° 55', consequently Venus will not transit the Sun either in passing her ascending or descending node.

106. Will Mercury transit the Sun in the year 1824?

107. Will Venus transit the Sun in the year 1826.

108. Will Mercury transit the Sun in the year 1825?

109. Will the Earth appear to transit the Sun to the inhabitants of Mars in the year 1823?

110. Will the Earth appear to transit the Sun to the inhabitants of Jupiter in the year 1824?

PROBLEM XI.

To find when any two given planets shall have a given Heliocentric Aspect, their Longitudes on January 1, 1823, *being considered given.*

RULE. Add the degrees in the given aspect to the longitude of either of the planets, and then take the difference of that sum, and the longitude of the other.

Then, as the difference of the daily motions of the two planets : 1 day :: the difference found above : the time required.

EXAMPLES.

111. At what time in the year 1824, will the Earth and Venus have a trine aspect?

Solution.—Lon. of Venus, January 1, 150° 2′, Earth's lon. 100° 6′. To the Earth's lon. add 120°, the sum is 220° 6′:—

$$\text{Then } \frac{220°.1 - 150°.0333}{1.6021 - .9856} = \frac{70°.0667}{.6165} = 113 +$$

days, answering to April 23, nearly.

112. When will Saturn and Herschell have a sextile aspect?

113. When in the year 1824, will Mars and Jupiter have a quartile aspect, their longitudes on January 1, being given?

114. When will Jupiter and the Earth be in conjunction in the year 1824?

115. When will the Sun and Saturn have a trine aspect in the year 1824?

116. When will Venus and Mars have a quartile aspect, in the year 1826?

117. When will Saturn and Herschell have a sextile aspect, after January 1st. 1824?

PROBLEM XII.

To find the Geocentric Place of any Planet on any particular day.

Rule—Find the longitude of the Earth and of the planet in the outermost circle, (Plate VII. Fig. 5.) representing the ecliptic; lay the edge of a ruler to the centre and to the earth's longitude, and make a mark with a pencil on the earth's orbit; then, in the same manner, make a mark on the planet's orbit: this being done, lay the edge of the ruler to the marks representing the Earth's and the planet's places in their respect-

ive orbits, and the part of the ecliptic intersected by the ruler, nearest the planet's place, will show its geocentric longitude.

EXAMPLES.

118. What is the geocentric place of Mercury, January 1st. 1821?

Solution. The longitude of the Earth is 3s. 10°, and of Mercury 6s. 21°; a ruler laid over these points in their respective orbits will cut the ecliptic in ♑ 19°, the geocentric place of Mercury as required.

119. What is the geocentric longitude of Saturn, April 17, 1821?

120. What is the geocentric longitude of Venus, Nov. 9, 1822?

121. What is the geocentric longitude of Jupiter, Aug. 19, 1824?

122. What is the geocentric longitude of Mars, December 28, 1828?

123. What is the apparent place of Mercury, October 6, 1821?

Obs.—It will be a very pleasing exercise to the student to construct a figure similar to the one in the plate abovementioned. Let him take from a scale of equal parts, 100 to an inch, 37 for the radius of Mercury's orbit, and 95 for that of the Earth, and, after describing two concentric circles for the orbits, describe two larger circles, the one radius about 3 inches, or 300 parts of the same scale, the other 305. Let these, as one, to represent the ecliptic, be divided into 12 equal parts, and subdivided into smaller parts according to the pleasure of the performer. He will then be enabled to perform the problem more truly than by the small figure in his book. The teacher would do well to propose other projections, in suitable proportions for the superior planets. *Editor.*

PART III.

GEOGRAPHICAL AND ASTRONOMICAL PROBLEMS, TO BE PERFORMED BY THE GLOBES.

THE TERRESTRIAL GLOBE.

Description of the various parts of, and the Lines drawn on, the Terrestrial Globe.

265. The terrestrial globe is a globe or sphere, made to represent the Earth, on which the kingdoms, oceans, towns, seas, &c. are depicted, according to their sizes, situations, &c.

266. This globe is, for conveniency's sake, fixed in a frame, the upper flat part of which, is denominated the wooden horizon, and is divided into three concentric circles.

267. The outermost circle* of the wooden horizon, is divided into twelve parts, in which the months, and the number of days each month contains is written.

268. The middle circle contains the names, and the order of the twelve signs of the zodiac;

* These circles are differently arranged on different globes. *Ed.*

and is so placed, that the day the sun enters any particular sign or degree of the ecliptic, is opposite that sign or degree.

Obs.—Against January 1st. in the outer circle, is 11° ♑, that is, on January 1st. the sun is in ♑ 11°, and as the earth is always in the opposite part of the ecliptic to the sun, it is in ♋ 11°.

269. The innermost circle is divided into four parts, each containing 90°; around which are placed the points of the mariner's compass.

270. The brazen circle, which encompasses the globe, and is useful in keeping the globe steadily in its frame, is called the brazen meridian, and is divided into 360°.

271. The two brass circles which are placed on the globe, and fixed at opposite points of the brazen meridian, are called hour circles; each is divided into 24 parts, to represent the hours in a day.

272. From the centre of one of the hour circles to the centre of the other, is fixed a wire, which goes quite through the globe; on this wire it turns, and this is called the axis of the globe.

273. The two extreme points of this axis, which are fixed in the brazen meridian, are called poles; one is denominated the north, and the other the south pole.

274. Upon the surface of the globe are drawn various lines, which geographers have invented for the more easily distinguishing the different parts of the earth.

275. Some of these lines are drawn on the globe, in the direction of the brazen meridian,

and encircle the globe, passing through both poles, and are called meridians.

There are 24 meridians drawn on the surface of most globes. They are consequently 15° asunder.

Obs.—Each of the meridians divides the globe into two *equal* parts; and they are, on that account, called *great* circles.

276. The circles which are drawn perpendicularly to these meridians and encompass the globe, are called parallel circles, because they are all parallel to each other.

277. The circle which is in the middle of the globe, and equally distant from each pole, and divides it into two equal parts, is called the equator.

278. The parallels are generally placed 10° asunder; so that there are eight parallels north, and eight south of the equator, and these being placed 10° asunder on the globe, are called parallels of latitude.

Obs—Each of these parallels divides the globe into two *unequal* parts; they are, therefore, called *small* circles, to distinguish them from the circles which divide the globe into two equal parts or *great* circles

279. At $23\frac{1}{2}$° on each side of the equator, are drawn two small circles, which are called tropical circles, or tropics. The northern is called the tropic of Cancer, and the southern the tropic of Capricorn.

280. At $23\frac{1}{2}$° distant from each pole, are likewise drawn two small circles. That encircling the north pole, is called the Arctic Circle, and that encircling the south pole, the Antarctic Circle.

Obs.—These circles divide the globe into five zones.

1. The North Frigid Zone, included between the north pole and the arctic circle.
2. The South Frigid Zone, included between the south pole and the antarctic circle.
3. The North Temperate Zone, comprehended between the arctic circle and the tropic of Cancer.
4. The South Temperate Zone, contained within the antarctic circle and the tropic of Capricorn.
5. The Torrid Zone, contained within, and bounded by the tropics.

281. The equator is numbered by degrees, from the meridian which passes through London, east and west round the globe, until such numbers increase to 180°.

282. The *apparent* path of the sun through the zodiacal signs, called the ecliptic, is likewise drawn thereon. The ecliptic is a *great* circle which intersects the equator in two opposite points, and is divided like the middle circle of the wooden horizon, into twelve parts; these signs, viz. ♈ Aries, ♉ Taurus, ♊ Gemini, ♋ Cancer, ♌ Leo, ♍ Virgo, ♎ Libra, ♏ Scorpio, ♐ Sagittarius, ♑ Capricornus, ♒ Aquarius, ♓ Pisces, are marked thereon.

283. The quadrant of altitude is a thin slip of brass divided into degrees. It is so contrived as to be capable of being fixed to any part of the brazen meridian.

284. The analemma is a projection of the sphere upon the meridian. This accompaniment is particularly useful in readily determining the Sun's declination on any particular day: which days are of an equal length, &c. &c.

GEOGRAPHICAL AND ASTRONOMICAL DEFINITIONS.

285. The latitude of any place on the terrestrial globe is its distance from the equator, in degrees, measured on the meridian, and can never exceed 90°.

286. The longitude of any place on the globe is the distance of its meridian from the meridian of London, measured on the equator, and can never exceed 180°.

287. The zenith of any place is the point immediately over head, and the nadir, the point directly under feet. The zenith and nadir are the two poles of the horizon, each being 90° distant therefrom.

288. The sun's place in the ecliptic, is the point of the ecliptic in which the sun appears as viewed from the earth, and is exactly six signs distant from the earth's place.

289. The declination of the sun on the globe is the nearest distance of the sun's place from the equator.

290. The amplitude of any celestial body, is the distance it rises from the east, and sets from the west, measured on the horizon.

291. A vertical circle is an *imaginary* circle passing through the zenith and nadir, cutting the horizon at right angles. On this circle the altitudes of the celestial bodies are measured, and it is illustrated by the quadrant of altitude fixed in the zenith,

292. The right ascension of any celestial body, is the distance of the meridian, which passes through that body, from the first point of Aries, measured on the equator.

Obs.—The right ascension of the Sun, is the distance of the meridian, which passes through the Sun's place, from the first point of Aries, measured on the equator.

GEOGRAPHICAL AND ASTRONOMICAL PROBLEMS, ON THE TERRESTRIAL GLOBE.

PROBLEM I.

To determine the Latitude of any place on the Globe.

RULE. Bring the given place to that part of the brass meridian which is numbered from the equator towards the poles; the degree on the meridian over the said place, is its latitude required.

EXAMPLES.

1. What is the latitude of Plymouth?
Ans. 50½° N.
2. What is the latitude of each of the following places? Athens, Aberdeen, Archangel, Astracan, Berlin, Boston, Brest, Bristol, Cadiz,

Cape of Good Hope, Copenhagen, Dover, Dublin, Edinburgh, Elba, Finisterre (Cape,) Glasgow, Helena, (St.) Ispahan, Lima, London, Madras, New-York, Oporto, Portsmouth, Quebec, and Washington.

3. What places on the Earth have the same latitude as Cape Horn, Stockholm, and Buda?

4. What inhabitants of the earth, have their days of the same length as those of Plymouth, Cagliari, and Grand Cairo?

PROBLEM II.

To find the Longitude of any given place.

RULE. Bring the given place to the brass meridian, and observe the number of degrees marked on the equator, under the brass meridian, which is the required longitude of the given place.

Note.—If the numbers on the equator are increasing from the left towards the right hand, the longitude is east; if from the right towards the left hand, it is west.

EXAMPLES.

What is the longitude of Plymouth?
Ans. $4\frac{1}{4}°$ W.
What is the longitude of Dover?
Ans. 1° E.

5. Required the longitudes of the following places: Aberdeen, Barbadoes, Canton, Buda,

Gibraltar, Lisbon, Nankin, Jeddo, Cape Comorin, and Philadelphia.

6. What places on the Earth have the same longitudes as Palermo, Alexandria, and Cork?

7. To what places on the Earth is the Sun south the same time it is at Plymouth, Paris, and Madrid?

8. What places on the Earth have midnight, the same time as the inhabitants of Plymouth, Irkutsk, Tobolsk, and Stockholm?

9. What places on the Earth have their hours at the same time as the inhabitants of London, and Versailles?

10. What places on the Earth have no longitude?

PROBLEM III.

Having the Latitude and Longitude of any place given, to find that place.

RULE. Bring the given longitude found on the equator, to that part of the brass meridian which is numbered from the equator towards the poles, and under the given latitude, on the brass meridian, is the place required.

EXAMPLES.

What place is that whose latitude is $50\frac{1}{2}°$ N. and longitude $4\frac{1}{4}°$ W.

Ans. Plymouth.

11. What places have the following latitudes and longitudes?

Latitudes.	*Longitudes.*
50° N.	6° W.
56 N.	67½ W.
6¼ S.	107 E.
3½ S.	102¼ E.
64½ N.	39 E.
58 N.	9 W.
39 N.	77¼ W.
22½ N.	88½ E.

12. What place is that whose latitude is as much south as Plymouth is north; whose longitude is 180° from that of Plymouth; the inhabitants of that place have their feet against those of the inhabitants of Plymouth, and are called Antipodes?

PROBLEM IV.

To find the difference of Latitude of any two places.

RULE.—Find the latitude of each place by Problem I. and if they are both north, or both south, their *difference* will be their difference of latitude sought; but if one is north, and the other south, their *sum* will be their difference of latitude required.

EXAMPLES.

What is the difference of latitude between Plymouth and Rome?

Plymouth, -	$50\frac{1}{2}$ N.
Rome, - -	41 N.
Ans.	$9\frac{1}{2}^{\circ}$ Diff. required.

What is the difference of latitude between London and Cape Horn?

London -	$51\frac{1}{2}^{\circ}$ N.
Cape Horn, -	56 S.
Ans.	$107\frac{1}{2}^{\circ}$ Diff. required.

13. What is the difference of latitude between the following places?

London and Paris,	Pekin and St. Salvador,
Madrid and Buda,	Washington and Calcutta,
Petersburgh and Turin,	Berlin and Bristol,
Copenhagen and York.	Cork and Moscow.

14. How many degrees is Moscow north of Plymouth?

15. What two places on the globe have the greatest difference of latitude?

PROBLEM V.

To find the Difference of Longitude of any two places.

RULE.—Find the longitude of each place by Problem II. and if they are both east or both

west, the difference between the greater and the lesser longitudes, will be their difference of longitude required; but if one be east and the other west, the sum of their longitudes will be their difference of longitude sought.

Note.—If the sum of their longitudes be greater than 180°, subtract it from 360°, and the remainder will be the difference of longitude.

What is the difference of longitude between Plymouth and Cork?

Longitude of Cork.	$8\frac{1}{2}°$ W.
Longitude of Plymouth,	$4\frac{1}{4}$ W.
Ans.	$4\frac{1}{4}°$

What is thedifference of longitude between Cape St. Roque and Bombay?

Long. of Cape St. Roque	35° W.
Long. of Bombay - -	71 E.
Ans.	106°

16. What is the difference of longitude between the following places?

London and Baltimore,	Syracuse and Malta,
Copenhagen & the Lizard,	Calcutta and Cadiz,
Jeddo and Mocha,	Brest and Inverness,
Baku and Buda,	Rome and Cape Horn,
Surinam and Palermo,	Candi and the Lizard.

17. What is the greatest difference of longitude any two places can have, and name four places which are so situated?

PROBLEM VI.

Having the Time at any particular Place given, to find the time at any other place.

RULE.—Bring the given place and the given hour on the hour circle, to the brass meridian, and turn the globe until the proposed place is under the meridian, the hour cut thereby is the time required.

Or, without a Globe.

Divide the difference of longitude of the two places by 15, and the quotient will be their difference of time. If the place to which the time is required be east of the other, add; if to the west, subtract their difference of time to or from the time given; and the sum or remainder will be the time required.

EXAMPLES.

When it is 12 o'clock at London, what is the time at Dresden?

Ans. 1¼ P. M.

18. When it is 4 o'clock P. M. at London, what is the time at Paris?

19. What is the time at Buda, when it is 7 hrs. 16 min. A. M. at Madrid?

20. What is the hour at Barcelona when it is noon at Calcutta?

21. When it is midnight at New-York, where is it noon?

22. What places on the Earth are 45° E. of London?

23. When it is noon at Edinburgh, to what places has the sun passed the meridian two hours?

24. What places have their time two hours earlier than the inhabitants of Aberdeen?

25. In an eclipse of the moon it was observed to begin at London 11 hrs. 37 min. P. M. what time did it commence at Moscow and at Dublin?

26. What places have their time the same as the inhabitants of Madrid?

27. When it is midnight at Mecca, where are the people dining, supposing they dine at 1 o'clock, P. M.?

28. On September 1st. 1821, 3 hrs. 47 min. A. M. Jupiter's first satellite was eclipsed at London; what is the longitude of that place, where the said eclipse began at midnight?

PROBLEM VII.

To find the Distance of any two places on the Globe.

RULE.—Lay the graduated edge of the quadrant over the two places, and the degrees between them, multiplied by $69\frac{1}{2}$, will be their distance in English miles.

EXAMPLES.

What is the distance between Plymouth and Paris?

Ans. 4°, or 278 miles.

29. What is the distance between the following places?

London and Rome. York and Buda. St. Helena and Cadiz. Paris and Palermo. Cork and Dover. Pekin and Madrid. Moscow and Stockholm. Oporto and Jeddo. Ispahan and Ivica.

30. How long would a ship be sailing from Plymouth to Philadelphia, at the uniform rate of 3 miles per hour?

PROBLEM VIII.

To find the Antœci, Periœci, and Antipodes of any given place.

DEFINITIONS.—1. The Antœci are those who live in the same latitude and longitude, only one has north latitude and the other south.

2. The Periœci are those who have the same latitude and opposite longitudes.

3. The Antipodes are those who have opposite latitudes and longitudes.

RULE.—Bring the given place to the brass meridian, and the Antœci, Periœci, and Antipodes, may be found immediately by attending to the above definitions.

EXAMPLES.

What are the Antœci, Periœci, and Antipodes of London?

Ans. Antœci, the inhabitants of the South Sea, east of the Sandwich Islands.

Periœci, the inhabitants of the Islands of the Northern Archipelago.

Antipodes, the inhabitants of the lowest extremity of New Zealand.

31. What are the Antœci of Petersburgh; the Periœci of Madrid, and the Antipodes of Calcutta?

32. If a hole were to be bored from Philadelphia through the centre of the earth and continued, in what part of the earth would the cavity terminate?

PROBLEM IX.

To rectify the Globe, or to put the Globe in such a position as the Earth actually is, on any given day at noon; to tell the Sun's declination and right ascension; or to find on what day the Sun has any given Declination.

RULES.—1. Raise or depress the pole in such a manner that it may be so many degrees above the horizon, as are equal to the latitude.

2. Find the day of the month in the outer circle of the wooden horizon; and against it, in the middle circle, is the Sun's place in the ecliptic.

3. Find the corresponding Sun's place in the ecliptic, which bring to that part of the brass meridian numbered from the equator towards the poles; and put 12 on the hour circle to the said meridian. The globe is then rectified as required.

4. The degree on the brass meridian, directly over the Sun's place, or against the given day, on the analemma, is the Sun's declination; the degree on the equator, cut by the brass meridian, is his right ascension; and the day answering to any given declination is the day on the analemma, or the day answering to the Sun's place in the ecliptic, immediately under it.

EXAMPLES.

Rectify the globe for London, May 14, at noon.

Solution.—1. Let the north pole be elevated $51\frac{1}{2}°$ above the horizon.

2. Against May 14th, on the outer circle of the horizon, is ♉ 24°.

3. Then ♉ 24° on the ecliptic, being brought to that part of the brass meridian which is numbered from the equator towards the poles, and 12 on the hour circle being brought there also, the globe is rectified as required: his declination is about 18° N. and his right ascension 52°.

33. Rectify the globe for New-York, July 8th, and tell me the Sun's declination and right ascension.

34. Rectify the globe for Madrid, and tell me the day the Sun has $19\frac{1}{2}°$ N. declination.

35. Rectify the globe for Oporto, January 8th, and tell me the Sun's declination, right ascension, &c.

36. Rectify the globe for Madras, and tell me the day the Sun's declination is 20° S.

37. Rectify the globe for Cape Horn, December 21st, and tell me the Sun's declination.

38. What is the difference between the latitude of Gibraltar, and the Sun's declination January 4th?

39. How many degrees difference is there in the altitude of the Sun at London, January 5th, and April 4th?

40. How many degrees is the Sun apparently lower at Vienna on December 21st than on June 21s?

41. How far is the sun south of Madrid, Oct. 4th at noon; and how much farther south is he at that time, than on the 6th of July at noon?

42. If the Sun's rays shine 90° from its declination, to what degree of north latitude will it extend on February 4th; and what is his right ascension on that day?

43. To what degree of north latitude will the Sun extend on December 21st?

44. How many degrees will the Sun's rays extend over the north pole, on April 18th?

45. On what day will the inhabitants of Spitzbergen begin to receive the Sun's rays, after having been involved in gloomy twilight?

46. On what day is the Sun's right ascension 85°?

PROBLEM X.

To find the places on the Earth where the Sun is vertical; what places are deprived of the Sun's rays; and those that have constant sunshine, on any given day.

RULE.—Find the sun's declination by the last Problem: elevate the pole so as to bring the degree of declination to the zenith; revolve the globe quite round its axis, and all places passing under the declination, will have the sun vertical; those places which do not descend below the horizon will have constant sunshine; and to those which do not ascend above the horizon, the sun will be invisible.

Note.—When the sun's centre is over the equator, both poles will be illuminated.

EXAMPLES.

On May 4th, to what places of the Earth is the Sun vertical; where does he not shine; and what places have constant day?

Ans.—The Sun is vertical to the inhabitants of Acapulco, Guadaloupe, Hydrabad, &c. &c. He does not set to the inhabitants of Nova Zembla, Spitzbergen, &c. And he does not shine at all to all places within 15° of the south pole.

47. To what places is the Sun vertical, July

16th; and what parts of the Earth have perpetual sunshine?

48. To what places on the earth does the sun not shine on November 12; where is he vertical; and what places have constant day-light?

49. What inhabitants of the earth have no shadow when the sun is on the meridian, April 18th?

50. What inhabitants of the earth have the sun visible in the north, on December 16th?

51. Is the sun ever vertical to the inhabitants of Calcutta; if so, on what days?

52. How many degrees does the sun overshadow the south pole on May 16th? how much south of Plymouth is the place where he is vertical?

53. How many degrees south of St. Petersburgh, is the place where the sun is vertical on April 8th?

54. How much further north is that place where the sun does not set, on May 18th, than Brest is? and what is the difference of latitude between London and the place where the sun is vertical, on that day?

PROBLEM XI.

To find where the Sun is vertical; to what places he is rising; and to what places he is setting at any time on a given day, at a given place.

Rules.—1. Bring the given place, and the given time, on the hour-circle, to the brass meridian.

2. Find the Sun's declination, and note the degree on the brass meridian equal thereto.

3. Turn the globe until 12 at noon comes to the brass meridian; then to the place under the Sun's declination, the Sun is vertical; to the places on the eastern edge of the horizon, he is rising; to those on the western edge he is setting; and to those places which are in the north and south parts of the horizon, the Sun appears in the horizon the whole day.

EXAMPLES.

When it is 7 o'clock A. M. at London, July 8th, where is the sun vertical; to what places is he rising and setting; and where does he continue in the horizon the whole day?

Ans. The Sun is vertical at Burhampour; he is rising to the Solomon Islands, east of New Guinea; he is setting to the west coast of Africa, Cape Verd, &c. and he appears in the horizon the whole day to the northern parts of Hudson's Bay, &c.

55. When it is 5 hours A. M. at Plymouth, April 8th, where is the Sun vertical, rising and setting, &c.

56. When it is 9hrs. 30 min. P. M. at Madras, November 6, where is the Sun rising, setting, and vertical?

57. When it is 8 hrs. A. M. at Petersburgh, August 4th, where is it midnight; where is the Sun vertical, rising and setting?

58. Where is the Sun in the zenith, April 17, when it 3 hrs. P. M. at New-York?

PROBLEM XII.

To find the time the Sun rises and sets; the length of his diurnal and nocturnal arcs; his oblique Ascension and Descension; with the length of day and night, on any particular day, at a given place.

RULES.—1. Rectify the globe for the latitude and Sun's place, by Problem IX.

2. Bring the Sun's place to the eastern edge of the horizon; the degree on the equator, cut by the horizon, is his oblique ascension; and the hour on the hour-circle, cut by the brass meridian, is the time he rises: bring the Sun's place to the western edge of the horizon, the degree of the equator cut thereby is his oblique descension; and the hour on the hour-circle under the brass meridian the time he sets; double the time of the Sun's rising, and it will be the length of the night; double the time of his setting, and it will be the length of the day; multiply the length of the day by 15°, and it will be the Sun's diurnal arc; multiply the length of the night by 15°, and it will be the length of his nocturnal arc.

Or, by the Analemma.

Elevate the pole to the latitude; bring the middle of the analemma, and 12 on the hour-circle, to the brass meridian; turn the globe eastward, until the given day comes to the horizon, and the hour-circle will show the time the

Sun rises; bring the given day to the western edge, and it will show the time he sets.

Note 1.—If the time the sun rises be taken from 12 hours, it will leave the time he sets: because he rises as long before noon, as he sets after noon.

2. The difference between the right and oblique ascension, is the ascensional difference; which, converted into time, at 15° an hour, is the time the sun rises and sets, from six o'clock.

EXAMPLES.

At Madras, August 16th, what time does the Sun rise and set; what is his oblique ascension and descension the lengths of the day and night, and the lengths of his diurnal and nocturnal arcs?

Ans. The Sun rises at 5¼ hrs. sets 6¾; the length of the day is 13 hrs. and of the night 11 hours.; his nocturnal arc is $15° \times 11 = 165°$, and his diurnal arc $13 \times 15° = 195°$; his oblique ascension is 144°, and his oblique descension 151°.

60. What time does the Sun rise and set on July 18th, at Petersburgh?

61. What is the length of the day, the Sun's oblique ascension and descension, and his diurnal and nocturnal arcs, on June 21, at London?

62. What is the difference in the lengths of the longest and shortest days at York?

63. What is the length of the Sun's diurnal arc at Calcutta, July 17th?

64. How much longer is the day at North Cape than at Plymouth, August 16th?

65. What is the length of the night at Petersburgh, on December 21st?

66. How much longer is the day at Plymouth than at Paris, on April 4th?

67. What time does the sun rise and set at Madagascar, on July 8th?

68. What is the length of the longest and shortest days at London, Paris, Alexandria, and Aleppo?

PROBLEM XIII.

To find how long the Sun continues above or below the Horizon, to any place in the Frigid Zones.

RULE.—Subtract the latitude of the given place from 90°, the remainder will be the Sun's declination, when constant day begins and ends there; the space of time elapsing between the days answering to the Sun's declination, will be the time the Sun continues above or below the horizon, at the given place.

EXAMPLES.

How many days does the Sun illuminate the southern part of Nova Zembla, latitude 70° north?

Solution.—$90° - 70° = 20°$, the sun's declination when he begins constantly to shine there. The days answering to 20° N. declination are, May 21st. and July 23d.. From May 21st. to

July 23d, are 63 days; the time the sun continues above and below the horizon at the given place.

69. Captain Parry, and the crew of the British ship Griper, when searching for a north-west passage to India, in the year 1819, wintered in Baffin's Bay, in latitude 76° N. how long were they deprived of the sight of sun?

70. How long does the sun shine constantly to a place in latitude 72½° N.?

PROBLEM XIV.

To find the Sun's Altitude and Azimuth, on any Day, at any place and hour, and his Meridian Altitude.

RULES.—1. Rectify the globe for the latitude and sun's place, by Problem IX.

2. Fix the quadrant in the zenith, turn the globe until the given hour is under the brass meridian: lay the quadrant over the sun's place, and the number of degrees thereon is the sun's altitude, at the given hour.

3. The number of degrees in the inner circle of the horizon, from the point where the quadrant intersects it to the south, is the sun's azimuth.

4. The number of degrees from the sun's declination, on the the brass meridian to the horizon, is the sun's meridian, or greatest altitude.

Note.—The rule by the analemma is the same; only, bring the middle of the analemma, instead of the Sun's place, to the brass meridian, and use the given day, as you used the Sun's place in the ecliptic.

EXAMPLES.

What are the sun's altitude and azimuth on January 8th, 10 hrs. A. M. at London?

Ans. The sun's altitude is 12°, and his azimuth, S. 25 E

71. What is the sun's meridian altitude at Cork, April 18th?

72. What is the sun's azimuth and altitude at 10 o'clock A. M. at Barbadoes?

73. What is the sun's altitude at 6 o'clock, A. M. on July 5th, at Vienna?

74. What are the sun's greatest and least meridian altitudes at London?

75. June 10th, at Cape Comorin, required the time of the sun's appearing twice on the same azimuth?

76. What are the azimuth and altitude of the sun, when his declination is 18° S. at 11 hrs. A. M. at Madrid?

77. What is the altitude of the sun at Pondicherry, at 9 hrs. A. M. April 18th?

78. What is the sun's azimuth, at 9 A. M, July 8th, at Buda, with his meridian altitude there on that day?

PROBLEM XV.

To find the Sun's rising and setting Amplitude, on any given day.

RULE.—Rectify the globe for the latitude and sun's place, by Problem IX.

Turn the globe until the sun's place comes to the eastern edge of the horizon; and the num-

ber of degrees on the inner circle, counting from the east, is his rising amplitude: bring the sun's place to the western edge of the horizon, and the number of degrees on the inner circle, counting from the west, is his setting amplitude.

Note.—The rule by the analemma is the same; only, bring the middle of the analemma, instead of the Sun's place, to the brass meridian; and use the given day, as you used the Sun's place in the ecliptic.

EXAMPLES

What is the sun's rising amplitude, on April 18th, at London?

Ans. E. 20° N.

79. What is the greatest rising amplitude the sun has at Paris?

80. How many degrees doth the sun set from the west, at Oporto, December 16?

81. Does the sun rise to the north or south of the east, at Palermo, July 19th?

82. What are the sun's rising and setting amplitudes, at Moscow, November 24th?

83. What time does the sun rise at Lisbon, Nov. 8th; and what is his setting amplitude?

84. July 17th, the sun's amplitude was observed to be E. 18 N.? what was the latitude?

85. Nov. 22d, the sun's amplitude was observed to be E. 29 S.; what was the latitude?

PROBLEM XVI.

To find the Beginning, End, and Duration of Twilight, at any given place, on a given day.

RULES.—1. Rectify the globe for the latitude, and sun's place, by Problem IX.

2. Fix the quadrant in the zenith, and turn the globe east, until the sun's place touches 18° on the quadrant below the horizon; the hour on the hour-circle, under the brass meridian, is the time the twilight begins in the morning: turn the globe west, and proceed as above directed, and you will obtain the time the twilight ends in the evening.

The duration of morning twilight, is the time from its commencing until sun-rising; or the duration of evening twilight, is the time from sun-setting, to the time the sun takes to descend 18° perpendicularly below the horizon. If the sun does not descend 18° perpendicularly below the horizon, twilight will continue from sun-setting to sun-rising, and there will be no night.

Note.—The rule by the analemma is the same; only, bring the middle of the analemma, instead of the Sun's place, to the brass meridian; and use the given day, as you used the Sun's place in the ecliptic.

EXAMPLES.

At what hour does morning twilight begin and end, at London, February 19th?

Ans. Day-light commences at 5 hrs. A.M. and ends at 7 hrs. P. M.

86. At what time does the morning twilight begin at Moscow, September 19th?

87. At what hour does darkness encompass the atmosphere of Washington, March 29th?

88. How many hours from day-break to sun-setting, at Baden, November 9th?

89. How long does twilight continue at Calcutta, September 7th?

90. What is the length of twilight at Cambridge, October 13th?

91. What is the difference in the length of the twilight on April 4th, and November 1st, at London?

92. What is the difference in the length of the twilight at Malta and Plymouth, on April 3d?

PROBLEM XVII.

To find the Beginning, End, and Continuation of Constant Day at any given place.

RULES. 1. Add 18° to the given latitude.

2. Subtract that sum from 90°, and the remainder will be the sun's declination, when constant day begins; the space of time elapsing between the days corresponding to the sun's declination, will be the time that constant day continues at the given place.

Note.—If the sum of the latitude and 18° be more than 90°, subtract 90° from that sum, and the remainder will be the Sun's declination, of a contrary name to the latitude.

EXAMPLES.

When does constant day begin, and how long does it continue at London?

Solution.—The lat. of London $51\frac{1}{2}°$ N. Then $51\frac{1}{2}+18° = 69\frac{1}{2}°$. And $90°-69\frac{1}{2} = 20\frac{1}{2}°$ = the sun's declination when constant day begins and ends; the days answering to which are May 23d, and July 20th; the space of the time between these days is 58 days, the time required.

93. At Petersburgh, when does constant day begin, and how long does it continue?

94. At Greenland, when does constant day begin, and how long does it continue?

95. At Labrador, when does constant day begin, and how long does it continue?

96. At the North Pole, what is the duration of twilight?

97. At North Cape, what is the duration of twilight?

PROBLEM XVIII.

To find the days when the Twilight is the shortest in any given latitude.

RULES. 1. Elevate the pole to the latitude.

2. Bring the first degree of Libra on the ecliptic to the eastern edge of the horizon, and fix the quadrant on the zenith. Keep the globe steady, and bring 18° on the quadrant to touch the ecliptic under the horizon: the day corresponding to the sun's place, cut by 18° on the quadrant, is the day required.

EXAMPLES.

At Cambridge,* latitude 52¼° N. on what day of the year is the twilight shortest?

Solution.—The globe being elevated to 52¼°, the latitude of Cambridge; the quadrant being screwed in the zenith, and 1° of Libra brought to the eastern edge of the horizon; 18° on the quadrant will cut the ecliptic under the horizon in 20° of Libra, the day answering to which is October 12th, and the day when the sun's declination is the same as October 12th, is March 2d, the two days when twilight is shortest at Cambridge.

98. At Plymouth, on what days is the twilight shortest?

99. At Edinburgh, on what days is the twilight shortest?

100. At Madras, how long does twilight continue when it is shortest?

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* The solution of this question has caused more trouble to mathematicians than almost any other; it has consequently been proposed and answered various times, in the principal periodical mathematical publications, with the hope of obtaining a *pure* spherical solution, as most of the gentlemen who have analysed it, have had recourse to fluctions, and therefore their investigations have been unintelligible to young mathematicians. This is the first book in which the question was ever solved by the globe, and were it not that it is quite foreign to the design of the present treatise, the author would cheerfully investigate the problem, and show on what principles he had obtained the rule.

101. At Paris, how long does twilight continue when it is shortest?

102. At New Orleans, what is the length of twilight, when it is shortest?

PROBLEM XIX.

By knowing the time when a Lunar Eclipse will happen, to tell the places where it will be visible.

RULES. 1. Find the place to which the sun is vertical at the given time, by Problem XI.

2. Then as the sun is visible to all the places above the horizon, so the moon, being in opposition to the sun, at the time of her being eclipsed, is visible to all the places below the horizon, and consequently will appear eclipsed to all those places.

EXAMPLES.

On February 6th, 1822, at $5\frac{1}{2}$ hours A. M. there was an eclipse of the moon; where was it visible?

Ans. In the whole of North and South America, and to the eastern coast of Africa?

103. On January 6th, 1824, at 9 hrs. A. M. the moon will be eclipsed; where will it be visible?

104. On June 22d, 1880, at 2 hours P. M. the moon will be eclipsed; where will it be visible?

105. On March 9th, 1830, at 2 hours P. M.

the Moon will be eclipsed, where will it be visible?

106. June 8th, 1918 at $11\frac{3}{4}$ hours P. M. the Moon will be eclipsed: where will it be visible?

PROBLEM XX.

By knowing the time when a Solar Eclipse will happen, to find the places on the Earth where it will be visible.

RULE.—Find where the sun is vertical (by Prob. XI.) at the given hour; and bring the place to the zenith; the eclipse, if a considerable one, will be visible to most of the places above the horizon.

EXAMPLES.

On March 4th, 1824, at 6 hrs. A. M. there there will be an eclipse of the Sun; where will it be visible?

Ans. It will be visible to the whole of Asia, New Holland, to the greater portion of Africa, the northern parts of Europe, as Russia, Siberia; to the Great Southern and Indian oceans, &c.

107. On May 15th, 1836, at $2\frac{1}{2}$ hours P. M. there will be an eclipse of the Sun; where will it be visible?

108. On November 29th, 1826, at $11\frac{1}{2}$ hours A. M. there will be an eclipse of the Sun; where will it be visible?

109. On March 4th, 1840, at 4 hrs. A. M. there will be an eclipse of the Sun; where will it be visible?

THE CELESTIAL GLOBE.

A description of the various parts of, and the lines drawn on the Celestial Globe.

293. The Celestial Globe is a sphere, designed to represent the appearance of the heavens; the fixed stars being depicted thereon; according to their apparent magnitudes, and their situations with respect to each other.

294. The constellations into which astronomers have so fancifully divided the stars, are divided one from an other by dotted lines, painted green upon some globes; and upon others, the stars are nearly eclipsed by the creatures themselves being figured thereon.

295. The celestial globe, by turning on its axis, represents the apparent motion of the stars from east to west.

296. The ecliptic is not only drawn and divided, as on the other globe, but the months, and days the Sun is in any particular sign, are written underneath in Latin.

297. On each side of the ecliptic are drawn circles parallel thereto, extending 8° on each

side; this distance of 16° constitutes the zodiac, the sphere in which all the planets move.

298. The arctic and antarctic circles are drawn in the same manner as they are on the other globe, as are the tropical circles.

299. The poles of the ecliptic are in the polar circles; the poles in which the hour-circles are fixed are the poles of the equator; and the zenith and nadir are the poles of the horizon.

300. The meridians on this globe are all drawn through the poles of the ecliptic, in the same manner as the meridians on the terrestrial globe are drawn through the poles of the equator.

301. There are two great circles drawn through the poles of the equator; one passing through the first degree of Aries and Libra, called the Equinoctial Colure; and the other through the first degree of Cancer and Capricorn, called the Solstitial Colure.

302. The parallels of latitude, are all drawn parallel to the ecliptic, in the same manner as they are drawn parallel to the equator on the terrestrial globe.

303. The wooden horizon, brazen meridian, hour-circles, and quadrant, are similar on both globes.

DEFINITIONS.

304. The latitude of either of the heavenly bodies is its nearest distance to the ecliptic, and is north or south, in the same manner as the lati-

latitude of any place on the earth, is its nearest distance to the equator.

305. The longitude of either of the celestial bodies, is its nearest distance from the first degree of Aries, reckoned on the ecliptic. The longitude of the sun, is the distance of the sun's place in the ecliptic, from the first degree of Aries.

306. The declination of the stars or planets, is their nearest distance from the equinoctial.

Obs.—The declination of a star on the celestial, is the same as the latitude of a place on the terrestrial; and the right ascension of a star or planet, on the celestial, the same as the longitude of a place on the terrestrial globe.

PROBLEM XXI.

To find the Right Ascension and Declination of the Sun, the Stars, or Planets.

RULE.—Bring the Sun, the planet's place, (found by Problem VII. Planetary Problems.) or the given star, to that part of the brass meridian numbered from the equator towards the poles; the degree on the meridian is the declination, and the number of degrees between the brass meridian, and the first degree of Aries, is the right ascension.

What are the right ascension and declination of *a* Lyra, vel Vega?

Ans. Declination $38\frac{1}{2}°$ N. and right ascension $277\frac{1}{2}°$.

Required the right ascension of Jupiter, April 26th, 1824?

Solution.—Jupiter's longitude by Problem VII. Astronomical Problems, will be 106°, or 3ˢ 16°, and his right ascension by the globe 107½° nearly.

110. What is the right ascension of the Sun, Jan. 11th, Aug. 4th, Sept. 9th, and Nov. 16th?

111. What are the right ascensions and declinations of the following stars?

Sirius	Markab
Cor Hydra	Algenib
Spica Virginis	Arietis
Deneb	Betelgeux
Arcturus	*a* Lepus
Marsic	Regulus
Ras Alhagus	Vendemiatrix
ε Delphinus	Alphacca.

112. What are the right ascension of Venus, the Earth, Mars, Jupiter, and Saturn, on Nov. 16th, 1823?

PROBLEM XXII.

To find the latitude and longitude of any of the heavenly bodies.

RULE.—Bring the pole of the ecliptic immediately under the brass meridian; fix the quadrant over the pole of the ecliptic which is of the same name as the latitude of the star is; bring the edge of the quadrant over the given star; the number on the quadrant against the star, is its latitude, and the number of degrees on the ecliptic, intersected by the quadrant, counting from the first point of Aries, is its longitude.

EXAMPLES.

What are the latitude and longitude of Arcturus?

Ans. Latitude 31°N. and longitude 6ˢ 21½°.

113. What are the latitudes and longitudes of the following stars?

Cor Caroli	Kochab
α Andromeda	Alkes
Scheat Alperas	Mira
Arided	Ancha
Alderamin	Situla
Alioth	Altair
Dubhe	Zubenna Krabbi.

PROBLEM XXIII.

Having the Right Ascension and Declination of a Star, or Planet given, to find its place on the Globe.

RULE.—Bring the given degree of a right ascension on the equator to the brass meridian, and under the given declination, on the brass meridian, will be the star, or planet's place.

EXAMPLES.

What star is that whose declination is 12° 56' N. and right ascension 149° 25'?

Ans. Regulus.

114. What stars have the following declinations and right ascensions?

Dec.	Rt. Asc.	Dec.	Rt. Asc.
15° 44′ N.	174° 42′	8° 27′ S	76° 14′
16 5 N.	66 6	23 29 N.	53 54
8 27 S.	76 9	9 34 S.	46 32
45 47 N.	75 29	19 50 N.	25 54
7 21 N.	86 5	59 38 N.	11 11
16 26 S.	99 5	55 26 N.	7 19

115. On July 19th, 1824, the right ascensions and declinations of the planets are as follow: Mercury's right ascension 110¾° declin 23° N. Venus' right ascen. 116° dec. 22° N. Mars' right ascen. 197½°, declin. 8° S. Jupiter's right asc. 115½° dec. 21¾° N. Saturn's right ascen. 63° dec. 19¼° N. Herschell's rt. asc. 284½° dec. 23¼° S. Find their places on the globe.

PROBLEM XXIV.

The Latitude and Longitude of a Star, or Planet being given, to find its place on the Globe.

RULE.—Bring the pole of the ecliptic to the brass meridian, and fix the quadrant over it; bring the longitude on the ecliptic to the edge of the quadrant, and under the given latitude on the graduated edge thereof, you will have the star, or planet's place.

EXAMPLES.

What star is that whose latitude is 0° 28′ N. and longitude 4ˢ 26° 57′?

Ans. Regulus.

116. What stars have the following latitudes and longitudes?

Lat.	*Long.*	*Lat.*	*Long.*
25° 41′ N.	0ˢ 11° 25′	29° 15′ N.	9ˢ 28° 51′
12 35 N.	0 6 16	61 44 N.	9 12 26
59 55 N.	11 2 29	4 33 S.	8 6 52
21 6 S.	11 0 57	44 21 N.	7 9 22
26 43 N.	9 29 33	30 52 N.	6 21 22

117. On Sept. 1. 1824, the geocentric longitudes and latitudes of the planets are as follow: find their places on the globe. Mercury's long. 6ˢ 5° 10′, lat. 1° 41′ S. Venus' long. 5ˢ 18° 15′, lat. 1° 23′ N. Mars' long. 7ˢ 15° 29′, lat. 1° 3′ S. Jupiter's long. 4ˢ 3° 2′, lat. 0° 21′ N. Saturn's long. 2ˢ 7° 33′, lat. 1° 58′ S. Herschell's long. 9ˢ 11° 57′, lat. 0° 25′ S.

PROBLEM XXV.

To find the time any Star, or Planet rises, sets, or comes to the Meridian, on any given day, at a given place.

Rules—1. Rectify the globe for the latitude, and bring the given day on the ecliptic, and 12 on the hour circle, to the brass meridian.

2. Bring the given star, (or the planet's place, for a planet,) to the eastern edge of the horizon, and the hour on the hour-circle, cut by the brass meridian, will be the hour it rises; bring it to the western edge, and the hour-circle will show the time it sets; bring it to the meridian and the hour-circle will show the time it culminates.

EXAMPLES.

At what hour will Arcturus rise at London, July 18?

Ans. 10 hrs. P. M.

At what time will Jupiter rise, culminate, and set at London, July 31, 1824?

The days from Jan. 1. to July 31, are 213, and $213 \times .0831 = 17° 43'$, and $96° 22' + 17° 43' = 114° 5'$, and Jupiter's latitude, by N. Almanac is 0° 21′ N. Therefore Jupiter will rise at 3 hrs. A. M. culminate at 11 hrs. A. M. and set at 7 hrs. P. M.

118. At what time will Sirius rise, culminate, and set, August 7, at Plymouth?

119. At what time will Rigel rise, culminate, and set, Nov. 4, at Oporto?

120. At what time will Saturn rise, culminate, and set, at Madrid, Nov. 11, 1824?

121. At what time will Venus rise, Nov. 7, 1823?

122. Will Venus rise before or after the Sun, September 16, 1825?

123. What time will Sirius rise at Plymouth, March 4th?

124. What stars are on the meridian when Arcturus is rising, Nov. 6th, at Calcutta?

125. When Mars is on the meridian. Nov. 16th, 1827: what stars are rising and setting?

126. What hour does Jupiter culminate the meridian of Paris, Sept. 16th, 1829; and what stars are rising and setting then?

127. When Procyon is culminating at London,

Sept. 11th 1826, in what part of the heavens must I look for Mars?

128. What hour will Jupiter come to the meridian of Madras, on July 11th, 1824?

129. What stars are never below the horizon of Plymouth?

130. What time will Venus come to the meridian of Philadelphia, on Feb. 7th, 1833?

131. When the Pleiades are rising at London, Nov. 6th, what stars are setting?

PROBLEM. XXVI.

The Latitude, Day, and Hour being given, to find what Stars are rising, setting, and culminating.

RULES—1. Elevate the pole to the latitude, bring the given day on the ecliptic, and 12 on the hour-circle to the brass meridian.

2. Turn the globe until the given hour is under the brass meridian: then the stars on the eastern edge of the horizon are rising, those on the western edge are setting, and those under the meridian are culminating.

EXAMPLES.

At 9 hrs. P. M. Dec. 4th, at London, what stars are rising, setting, and culminating?

Ans. Corona Borealis, Altair, Varia, &c. are rising; Arietis, Almach, Cassiopeia, &c. are culminating, and Sirius, Cor Caroli, &c. are setting.

132. At 9hrs. A. M. At Plymouth, Aug. 6th, what stars are rising, setting, and culminating?

133. What stars are rising, setting, and culminating, at the following places, at the following times?

Madras, Aug. 6th, $4\frac{1}{2}$ hrs. P. M.
Paris, July 8th, 7 hrs. A. M.
Petersburgh, Nov. 9th, 6 hrs. P. M.
Gibraltar, Feb. 11th, $7\frac{1}{2}$ hrs. A. M.
Corsica, Oct. 16th, $11\frac{1}{4}$ hrs. P. M.
London, Dec. 13th, $9\frac{3}{4}$ hrs. A. M.

134. Is Mars above or below the horizon of York, June 18th, 7 hrs. A. M. 1823?

135. Is Saturn visible at Madrid, April 11th, 9 hrs. A. M.?

136. Is Jupiter above the horizon of Aberdeen, Nov. 17th, 1823 at 11 hrs. P. M.

PROBLEM XXVII.

To find the Azimuth and Altitude of any given Star, at any place, on a given day and hour.

RULES.—1. bring the given day on the ecliptic, and 12 on the hour-circle to the brass meridian, and elevate the pole to the latitude.

2. Fix the quadrant in the zenith, and turn the globe until the given hour is under the meridian.

3. Lay the graduated edge of the quadrant over the given star; the degree against it will be the star's altitude: and the degree against the quadrant, on the inner circle of the horizon,

from the north or south, will be the star's azimuth.

EXAMPLES.

What are the azimuth and altitude of Regulus at London, April 8th, 7hrs. P. M.

Ans. The Altitude of Regulus is 42°; and its azimuth N. 35 W.

137. What are the azimuth and altitudes of the following stars, at the respective times and places?

Aldebaran, London, Aug. 7th, 4hrs. A. M.
Archernar, Cape-Horn. Nov. 11th, 8hrs. A.M.
Antares, Paris, April 6th, 4hrs. A. M.
Sirius, Washington, Aug. 16th, 6½hrs. A.M.
Spica, Buda, Sept. 19th, 10¼hrs. A. M.
Castor, Moscow, Jan. 11th, 6¼hrs. P. M.
Capella, Pekin, April 26th, 11hrs. P. M.
Vega, Jeddo, July 17th, 10hrs. P. M.

PROBLEM XXVIII.

To find the rising and setting Amplitudes, and Meridian Altitude of any Star or Planet at any place on any day.

RULES.—1. Elevate the pole to the latitude and turn the globe until the given star, or planet's place comes to the eastern edge of the horizon, and the distance, on the inner circle of the horizon, from the point where the star, or planet intersects it to the east, is the rising amplitude; and by bringing it to the western edge,

and proceeding as before, you will obtain its setting amplitude.*

2. Bring the star to the meridian, and the distance of the star from the horizon will be its meridian altitude.

EXAMPLES.

What are the rising and setting amplitudes of Arcturus at London, with its meridian altitude?

Ans. E. 34° S. its rising amplitude: W. 34° S. its setting amplitude: and 58° its meridian altitude.

What will be the rising and setting amplitudes of Jupiter, April 4th, 1824, with his meridian altitude at New-York?

Solution.—Longitude of Jupiter (by Prob. VII. Planetary Problems) 14° 13′ of Cancer; Jupiter's lat. by Nautical Almanac 0° 7′ N. Then as this problem directs, the planet's rising amplitude will be found E. 30° N.; setting amplitude W. 30° N.; and its meridian altitude 72°.

138. Required the rising and setting amplitudes, and meridian altitudes of the following stars at the respective places:

Algol	at	Plymouth
Rastaben	—	Petersburgh
Alkes	—	Calcutta
Canopus	—	St. Helena
Fomalhaut	—	Madras
Capella	—	Plymouth
Alphacca	—	York.

* When using the globe for a planet, its longitude and latitude must be found by some Almanac, and a small mark for the planet's place, must be made on the globe with a soft lead pencil.

139. How long will Arcturus rise after the Sun, on Nov 16th, and what is the difference of their meridian altitudes, at London?

140. When Arcturus is setting on April 6th, at Paris, what stars are rising, setting, and culminating; and whether does Sirius rise before or after the Sun on that day?

141. What is the difference of the rising amplitudes of Sirius and Aldebaran at Plymouth, with the difference of their meridian altitudes?

142. When the Sun is setting, November 8th, at Madrid, what star is that which is rising, whose rising amplitude is E. 29° S.; and what star is that whose altitude is 31°, and azimuth S. 41° E.?

PROBLEM XXIX.

To determine whether Jupiter and Venus are morning or evening stars, on any particular day, at a given place.

RULES—1. Find the longitude of the given planet, (by Problem VII. Planetary Problems,) and the longitude of the sun.

2. Then if the longitude of the Sun be less than the longitude of the planet, it will be to the east of the Sun, and will set after him in the evening, consequently will be an evening star: but if the longitude of the Sun be greater than the longitude of the planet, it will be to the west of the Sun, and will rise before him in the morning, and will consequently be a morning star.

Note.—The time the planet rises may be found by Problem XXV.

EXAMPLES.

Is Venus a morning or an evening star, on May 18th, 1824?

Solution.—The days from January 1st to May 18th, are 139. Then 1 6021×139=222° 42′, and the long. Jan. 1, 150° 2′+222° 41′=373° 43′; therefore, 373° 43′ or 0ˢ 13° 43′ is Venus' longitude; the Sun's longitude, May 18th, is 1ˢ 27° 25′ which being greater, proves Venus to be a morning star.

143. Will Jupiter be a morning or evening star, August 17th 1829?

144. Will Venus be a morning or evening star, on November 29th, 1823?

145. What time will the beautiful planet Venus rise, August 16th, 1825?

146. What time will Jupiter rise and set, April 4th, 1824?

147. Will the planet Venus appear in the evening or morning of December 17th, 1823?

148. What is the difference of longitude between Jupiter and Venus on May 18th, 1824? and will either of them be visible in the evening: and what is the difference in the times of their culminating?

149. Will Saturn be above the horizon of Plymouth, September 13th, 1823, at 8 o'clock, P. M.?

PROBLEM XXX.

Having the Sun or any Star's rising or setting Amplitude on any Day, to find the Latitude of the Place.

RULES—1. Bring the Sun's place and 12 on the hour-circle, to the brass meridan.

2. Bring the Sun's place, or the given star, to the east, or west edge of the horizon, according as the rising or setting amplitude is given; and elevate or depress the pole, until the Sun's place, or given star, corresponds to the given amplitude: then, so many degrees as the pole is elevated, will the latitude of the required place be.

EXAMPLES.

What is the latitude of the place, where the Sun's rising amplitude is E. 26° N. on May 16th?

Ans. 46$\frac{1}{2}$° N.

150. What is the latitude of the place, where the rising amplitude of Sirius is E. 29° S.?

151. I observed the Sun to rise Nov. 4th, E. 23° S. in what latitude was I?

152. In what latitude will Rigel rise S. 68° E?

153. In what latitude is the Sun's setting amplitude W. 17° S. on August 14th?

154. In what latitude will Procyon rise E.S.E?

PROBLEM XXXI.

Having the Sun or any Star's Meridian Altitude given, to find the Latitude.

RULES—1. Bring the given day on the ecliptic, or the given star, to the brass meridian.

2. Elevate or depress the pole, until the given number of degrees is contained between the horizon and the Sun's place, or the given star; the number of degrees the pole is elevated is the latitude required.

EXAMPLES.

The meridian altitude of Arcturus was 48°, what was the latitude?

Ans. 61°.

155. Being at sea, I observed the sun's meridian altitude on July 7th, to be 49½°; what was the latitude?

156. The observed meridian altitude of Sirius was 27°; what was the latitude?

157. The altitude of Castor, when on the meridian, was 71°; what was the latitude?

158. How far south must I go from Plymouth, to lose sight of Pollux?

159. How many degrees south must a person travel from Petersburgh, to lose sight of the north polar star?

PROBLEM XXXII.

To find the Distance of any two Stars, one from an other.

RULE.—Lay the quadrant over the two stars, and the number of degrees between them, will be the distance required.

EXAMPLES.

How far distant is Rigel from Sirius?
Ans. 23°.

160. What is the distance between the following stars?

Aldebaran and Castor	Marcab and Scheat
Rigel and Procyon	Deneb and Antares
Vega and Altair	Arcturus and Fomalhaut
Capella & Betelgeux	Castor and Sirius.

PROBLEM XXXIII.

To find on what day any given Star passes a given Meridian, at a given hour.

RULE.—Elevate the pole to the latitude; bring the given star and the given hour on the hour-circle to the meridian; turn the globe until 12 at noon is on the meridian, the day on the ecliptic under the brass meridian is the day required.

EXAMPLES.

On what day will Arcturus pass the meridian of London at 7hrs. P. M.?

Ans. August 1st.

161. On what day will Sirius and the Sun be on the meridian of Bristol at the same time?

162. On what day will Procyon pass the meridian of Madrid three hours after the Sun?

163. On what day will Aldebaran be on the meridian of Paris, 9hrs. before the Sun?

164. On what day will Castor culminate 7hrs. before the Sun at Plymouth?

165. On what day will the Pleiades culminate at 4hrs. P. M. at Madras?

PROBLEM XXXIV.

On any given Day and Hour, at a given place, to find the Angle which the Ecliptic makes with the Horizon, called the Nonagesimal Degree.

RULES.—1. Elevate the pole to the latitude; bring the given day, and 12 on the hour-circle, to the brass meridian, and turn the globe until the given place is under the meridian.

2. From the point where the ecliptic intersects the horizon, observe the great circle which passes through the pole of the ecliptic, and note where the circle cuts the brass meridian; the distance from that point to the zenith is the angle

the ecliptic makes with the horizon, or the nonagesimal degree.

EXAMPLES.

166. What angle does the ecliptic make with the horizon, on July 6th, at 6hrs. A. M. at London.

Ans. $44\frac{1}{2}°$.

167. What is the altitude of the nonagesimal degree at London, on June 21st, and Dec. 21st, at 11hrs, A. M.?

168. Find when the nonagesimal degree is the least at Paris.

169. On what day will the altitude of the nongesimal degree at Cambridge be a maximum? On this depends the determination of the shortest twilight.

170 What angle does the ecliptic make with the horizon at Cambridge, on October 12th, 4hrs. 43' A. M.?

PROBLEM XXXV.

The Latitude of the Place, Day, and Hour being given, to represent the Appearances of the heavens, so as to tell the Name of any Star we may observe.

RULE.—Elevate the pole to the latitude; bring the given day on the ecliptic, and 12 on the hour-circle to the brass meridian; turn the

globe until the given hour is under the meridian: let the north pole be placed towards the north, and the eastern part of the globe to the east, the globe will then exactly represent the appearance of the heavens, and any star's name may be found by its situation with respect to other stars.

EXAMPLES.

Represent the appearance of the heavens, at Plymouth, January 3d, 7hrs. P. M.

Solution—Sirius has just risen: the beautiful constellation, Orion, is in the S. E.; the Pleiades, and Aldebaran, are approaching the meridian, appearing to the north-west of Orion; Arietis and Triangulum are on the meridian; the grand geometrical formed by Scheat, Markab, Algenib, and *α* Andromeda, the three former in Pegasus, and the latter in Andromeda, are in the south-west; the Dolphin, the Arrow, and the Hart, are nearly in horizon in the west.

171. Represent the appearance of the heavens at New-York, July 7th, at 6hrs. A. M. and tell me the principal stars visible.

PROBLEM XXXVI.

To find the Cosmical, Heliacal, and Achronical rising or setting of any Star; or to find on what Day any Star will have such rising or setting

DEFINITIONS.

1. When a star { rises / sets } at sun-rising, it { rises / sets } cosmically.

2. When a star { rises / sets } at sun-setting, it { rises / sets } achronically.

The heliacal { rising / setting } of any star, is when it first appears in the morning, or disappears in the evening, after having been immerged in the sun's rays.

Note.—Stars of the First magnitude appear when the sun is 12° below the horizon; second magnitude, 13°; third magnitude, 14°; fourth magnitude, 15°, &c.

RULES—1. Elevate the pole to the latitude; screw the quadrant in the zenith, and bring the given day on the ecliptic to the eastern edge of the horizon, and the stars there are rising cosmically; those on the western edge are setting cosmically.

2. If the day be required when any star rises or sets cosmically, after the globe is elevated to

the latitude, bring the star to the eastern edge for the cosmical rising, and to the western edge for the cosmical setting, the day on the ecliptic, cut by the horizon, will be the day required.

For the Achronical rising or setting,

Bring the given day on the ecliptic to the western edge of the horizon: those on the eastern are rising achronically, those on the western are setting achronically.

For the Heliacal rising and setting,

Bring the given day on the ecliptic to touch 12° below the eastern or western edge of the horizon respectively for the rising or setting, then the stars of the first magnitude, on the western or eastern part of the horizon, are rising or setting heliacally; by using 13°, 14° and 15°, instead of 12°, you have the stars of the second, third, and fourth magnitudes, which respectively rise and set heliacally.

EXAMPLES.

What stars rise and set cosmically, achronically, and heliacally, at London, July 8th?

Solution.—Betelgeux rises cosmically; Mirach sets cosmically; Scheat and Enir rise achronically; Cor Hydra sets achronically, Fomalhaut rises heliacally; and Spica Virginis, &c. sets heliacally.

172. On what day at London will Arcturus rise cosmically?

173. On what day at Madrid will Sirius rise achronically?

174. What stars set heliacally at York, August 7th?

175. When will Aldebaran rise at sun-rising, at Bristol?

176. When will Castor set cosmically at Paris?

177. When will the Pleiades set at sun rising, at Plymouth?

178. What stars will rise achronically at Petersburgh, August 17th?

179. What stars set heliacally, at Madras, November 13th?

180. Hesiod, a celebrated Grecian poet, says, that at Ascra, lat. 38° N. as the sun entered Pisces, Arcturus rose achronically: how many years ago did he live, supposing the precession of the equinoxes to be $50\frac{1}{4}$ seconds in a year?

181. When, in the year 1823, will Jupiter, Mars, and Venus respectively rise at sun-setting, at Plymouth?

182. When will Herschell, in the year 1824, rise at sun rising, at Madrid?

183. When, in the year 1823, will Jupiter rise and set cosmically, at London?

184. When, in the year 1823, will Mars be on the meridian at midnight, at London?

SUPLEMENTARY CHAPTERS.

CHAPTER I.

THE NATURE OF THE PLANETARY REVOLUTIONS.

THE Sun is the centre of the Solar System, and the planets harmoniously revolve around it, constantly describing the same curve, which curve is an ellipse, though approaching very nearly to a circle.

This truth has been most fully demonstrated by the most eminent philosophers and mathematicians; and though in the infancy of astronomy, various systems were propagated by different astronomers to account for the various phenomena of the heavenly bodies, the most remarkable of which systems were those of Ptolemy and Tycho Brahe, each of whom imagined the sun and planets to revolve around the earth, yet the present system now called Solar, Copernican, or Newtonian system, which naturally arose from the errors of others, has been so beautifully illustrated, and clearly demonstrated by its reviver, Sir Isaac Newton, and other mathematicians, that it must gain the assent of all who understand its nature. It would be impossible, within the limits of a treatise like the present, to give the various demonstrations of that or other astronomers at any length; but as it may be necessary for the young student, both to confirm him in the truths found in the former parts of this volume, for his more clearly beholding the harmony and sublimity of the noblest of Sciences, and at the same time to direct his attention to the wisdom and goodness of his Maker, we shall briefly, though clearly show, that the Solar

is the true system of the universe. It is a known principle in the laws of motion, that if any body revolve round an other as its centre, it is necessary that the central body be always in the plane in which the revolving body moves: (Emerson's Astronomy:) and therefore, if the sun move round the earth in a day, its diurnal path must always describe a circle whose plane must divide the earth into two equal hemispheres; to every portion of the earth the sun would always rise in the same part of the heavens, that is, it would at any particular place on the earth, always have the same rising and setting amplitude; (vide art. 290;) it would always rise due east and set due west; it would always have the same position; be on the same point of the compass, or have the same azimuth, at the same time every day; it would every day in the year have the same meridian altitude; the day would always be equal to the night, each equal to twelve hours: the sun would, to every portion of the earth, preserve that regular uniformity it does now at the equator, constantly rising and setting at six o'clock. The meridian altitude of the sun would always be proportionable to the inclination of the axis of the earth, if the axis were perpendicular to the plane of the earth and sun's centre; every portion of the earth would, every day of the year, invariably and uniformly receive the invigorating influence of the refulgent rays of the revolving orb, and at the poles, the sun would appear always in the horizon: if, on the contrary, the poles of the earth were parallel to the plane of the earth and sun's centre, the sun would illuminate both the poles constant-

ly on the same day, and appear in their zenith; and indeed, if the axis of the earth were inclined in any direction whatever, every portion of the earth would every day receive the rays of the sun, and be enlightened by its refulgence; but since the sun appears to rise in different parts of the horizon, that is, its rising amplitudes are different every day; that its azimuth is different at the same time on different days, that its meridian altitude is greater or less every day; that it does not rise every day at the same time; that it does not rise and set every day at six o'clock; and that the frigid zones of the earth do not every day in the year receive the rays of the sun; the sun can not revolve around the earth, and the earth consequently has a rotation on its axis to produce the *apparent* revolution of the sun. If the sun were to revolve around the earth once in twenty-four hours, as it constantly must describe the same curve, and as the sun must rise and set at the same time every day, there could be no variety of seasons; for, as the seasons are occasioned by the variety in the lengths of the day, and as the length of days must constantly be equal, so there could be no different seasons: here then we may discover the wisdom and kindness of our heavenly Father. The planets also, if *they* revolved around the earth as a centre, would invariably rise and set at the same time, attain to the same meridian altitude every day, and would *appear* to move regularly round in their respective orbits; but as they do not *appear* to move with regularity and uniformity, as sometimes they ap-

pear to remain fixed among that host, that innumerable multitude of stars which in every direction encircle the firmament; at other seasons they *appear* to revolve with a greater or with a lesser velocity, describing *different* portions of their orbits in the *same* time, and frequently *appear* to move retrograde or contrary to the order of the zodiac; they cannot revolve round the earth as a centre, and these appearances can only be accounted for by the revolutions of the planets, among which is the earth, harmoniously and regularly revolving round the sun: but the young astronomer may say, why does not the moon, which you have said revolves round the earth, always rise and set at the same time, attain to the same meridian altitude, &c. every day? These differences in the times of rising, setting, &c. &c. are occasioned by a composition of motions, one in the earth, and another in the moon; for while the moon is proceeding in her orbit round the earth, the earth is proceeding in its orbit round the sun; and the difference in their motions, or more philosophically, the difference of their daily longitudes, is the portion the moon has to advance in her orbit, later on one day than on a preceding; and so long as the earth takes to describe that portion of a great circle, so long will the moon rise later each evening, which is about three quarters of an hour. To exemplify this: At new moon, the sun, moon and earth, are in the same straight line, the moon being in the middle; then as the moon's orbit is situated nearly in the plane of the ecliptic, these bodies rise, attain the meridian, and set at the same

time, consequently, the moon is hidden, as her darkened hemisphere is towards the earth; but on the second day from her conjunction, she she has traversed $\frac{1}{30}$th part of her orbit (as she revolves round the earth in about 30 days)$=12°$, and as the earth has revolved only 1° in that time, the moon is then 11° to the east of the sun, then she adorns our western sky in the evening; so that she rises, as has before been observed, as much later every day as the the earth is describing an arc of 11°; so when the moon comes in opposition to the sun, and the earth is directly in a line between these luminaries, the moon rises in the eastern the moment the sun sets in the western horizon; the moon comes to the meridian at midnight, as the sun does at midday. Another reason why the moon does not uniformly describe the same arc, is, that her orbit is constantly varying; she, unlike all the planets, goes round her primary in a different curve every revolution; the places of her nodes are continually varying, while the apses of the earth, and the nodes of the planets, remain unalterably fixed; and were it not for these reasons, namely, the combinations of the motions of the earth and moon, and the difference of her orbicular curve, she would present those appearances to us which the sun would, if he revolved round us, and the same as the fixed stars actually do present; constantly and daily having the same meridian altitudes, the same rising and setting amplitudes; describing the same arc in the heavens, &c. &c. all of which phenomena are produced by the rotation of the earth on its axis.

CHAP. II.

THE CAUSES OF PLANETARY MOTION.

Sir Isaac Newton was the first who attempted to give a physical account of the motions of the Planets, which should accommodate itself to all the irregularities which astronomers have ever observed in their motions.

He demonstrated, that if the planets were supposed to gravitate towards the sun, and to one another, and at the same time to have a projecting force originally impressed upon them, the primary ones might all describe ellipses around that luminary, which would be in one of the foci of such elliptic orbit. The secondary planets might also describe ellipses about their respective primaries, without being disturbed by the continual motion of the centres of their revolution. This principle of gravitation is an inherent principle, or mutual affection in all kinds of matter, in order to their uniting and coalescing into a globular form, for their better preservation.

This principle of gravity is very frequently called the attraction of gravity, and the centripetal force, and it is one of the most universal principles in nature. We see and feel it operate on all bodies near the earth; it is by this operative power, this inherent principle, that a stone or heavy body projected in the atmosphere is compelled to descend to the earth again; it is by this power that a body thrown from the top of an edifice, immediately is drawn towards the centre of attraction; it is by this power that the planets, the satellites, and very probably the sun,

with all his attending planets, satellites, and comets, revolve constantly round their centre of gravity.

One very essential property of gravity is, that its attractive force is always equal to the quantity of matter in any body, and from the natural affinity which one particle of matter has to another, arises all the motion, and consequently all the mutation in the universe. By this, heavy bodies descend, and light ones ascend; by this, projectiles are directed, vapours and exhalations rise, rains descend, rivers glide, tides ebb and flow, the air presses, the planets revolve, comets proceed, and all the machinery of nature is in constant and majectic motion; it connects itself with us in all our peregrinations, our bodies as well as the planets are its subjects, and it is by this that our antipodes can stand with their feet directed to the centre of the earth, and consequently against ours. The projectile or centrifugal force, is that force by which the planets are affected, and which prevents their falling into the centre of gravity of the solar system: this force acts perpendicularly to the centripetal force, and preserves the planets in their orbits: and it is by the combination of these forces, that the whole universe is regulated.

CHAP. III.

THE MILKY WAY.

THE Milky Way, or *Via Lactea*, is, (says Dr. Herschel) a most extensive stratum of stars of various sizes, and our sun (with all its planets, satellites, and comets) is ONE of the heavenly bodies belonging to it: that eminent astronomer says, he viewed this shining zone in almost every direction, and found it composed of shining stars, whose number constantly increases or diminishes according to its apparent brightness to the naked eye. But, says he, in order to develope the ideas of the universe that have been suggested by my late observations, it will be best to take the subject from a point of view, at a considerable distance both of space and time. The laws of gravitation, which no doubt extend to the remotest regions of the fixed stars, will operate in such a manner, as most probably to produce the following remarkable effects:

1st. It will frequently happen that a star, being considerably larger than its neighbouring ones, will attract them more than they will be attracted by others that are immediately around them; by which they will be, in time, as it were, condensed about a centre; or, in other words, form themselves into a cluster of stars, of almost a globular form, more or less regularly so, according to the size and original distance of the surrounding stars. *This cluster of stars is called a Nebula.*

2d. The next case, which will happen almost as frequently as the former, is, where a few stars, though not superior in size to the rest, may

chance to be rather nearer each other than the surrounding ones, for here also will be formed a prevailing attraction in the combined centre of gravity of them all, which will occasion the neighbouring stars to draw together; not indeed, so as to form a regular globular figure, but, however, in such a manner as to be condensed towards the common centre of gravity of the whole irregular cluster. And this construction admits of the utmost variety of shapes, according to the number and situation of the stars which first give rise to the condensation of the rest.

3d. From the composition and repeated conjunction of both the feregoing forms, a third may be derived: when most large stars or combined small ones, are situated in long extended, regular, or crooked rows, hooks or branches; for they will also draw the surrounding ones so as to produce figures of condensed stars coarsely similar to the former.

4th. We may likewise admit of still more extensive combinations; when, at the same time, that a cluster of stars is forming in one part of space, there may be another collecting in a different, but, perhaps, not a far distant quarter, which may occasion a mutual approach towards their common centre of gravity.

5th. From this theoretical view of the heavens, which has been taken from a point not less distant in time than in space, we will now retreat to our own *retired* station, in *one of the planets attending a star* in its greatest combination with numberless others: and, in order to investigate what will be the appearances from the contracted

situation, let us begin with the naked eye. The stars of the first magnitude being in all probability, the nearest, will furnish us with a step to begin our scale. Setting off, therefore, with the distance of Sirius, or Arcturus, for instance, as unity, we will at present suppose, that those of the second magnitude are at double, those of the third, treble the distance, &c. Taking it for granted then, that a star of the seventh magnitude (the smallest supposed visible to the naked eye) is about seven times as far as one of the first; that an observer, who is enclosed in a gobular cluster of stars, and not far from the centre, will never be able with the naked eye to see to the end of it, for since, according to the above estimations, he can only extend his views to about seven times the distance of Sirius, it can not be expected that his eyes should reach the borders of a cluster, which has, perhaps, not less than fifty stars in depth every way around him. The whole universe to him, therefore, will be comprised in a set of constellations, richly ornamented with scattered stars of all sizes. Or, if the united brightness of a neighbouring cluster of stars should, in a remarkably clear night, reach his sight, it will put on the appearance of a small, faint, whitish, nebulous cloud, not to be perceived but with the greatest attention. Let us suppose him placed in an extended stratum, or branching cluster of millions of stars, such as may fall under the third order of nebula already noticed; here also the heavens will not only be richly scattered over with brilliant constellations, but a shining zone, or milky way, will be perceived

to surround the whole sphere of the heavens, owing to the combined light of those stars which are too small, that is, too remote to be seen. Our observer's sight will be so confined, that he will imagine this single collection of stars, though he does not perceive even the thousandth part of them, to be the whole contents of the Heavens. Allowing him now the use of a common telescope, he begins to suspect that all the milkiness of the bright path which surrounds the sphere may be owing to stars. He perceives a few clusters of them in various parts of the heavens, and finds, also, that there is a kind of nebulous patches; but still his views are not extended to reach so far as to the end of the stratum in which he is situated; so that he looks upon these patches as belonging to that system which to him seems to comprehend every celestial object. He now increases his power of vision; and, applying himself to a closer observation, finds that the Milky Way is indeed no other than a collection of very small stars. He perceives that those objects which had been called *nebulæ*, are evidently nothing but clusters of stars; their number increases upon him, and when he resolves one nebula into stars, he discovers ten new ones which he can not resolve; he then forms the idea of immense strata of fixed stars, or clusters of stars, and of nebulæ; still going on with such interesting observations, he now perceives that all these appearances must naturally arise from the confined situation in which he is placed. Though the words condensation, cluster, &c. of stars, frequently occur, we are

(says the eminent Mr. Vince,) in no way to imagine that any of the celestial bodies in our nebula are nearer to one another than we are to Sirius, whose distance is supposed to be not less than 400,000 times the distance of the Sun from us, or thirty-eight millions of millions of miles. The whole extent of the nebula being in some places near 500 times as great, must be such that the *light* of a star placed at its extreme boundary, supposing it to fly with the velocity of twelve millions of miles every minute, must have taken near 3000 years to reach us! whence Young, in his Night Thoughts, says,

> "How distant some of the nocturnal suns:
> So distant, says the sage, 'twere not absurd
> To doubt, if beams, set out at Nature's birth,
> Are yet arrived at this, our foreign world;
> Yet nothing half so rapid as their flight."

"Every star, then, may be considered as the centre of some magnificent system, irradiated by its beams, and revolving about it by its influence. Thus is the empire of God magnified; his power, wisdom, and goodness made manifest. He is not glorified in one Earth, or in one system of worlds, but in an indefinite number. Could we dart to the loftiest apparent star, we should there see other skies expanded; other suns distributing their inexhaustible beams of day; other stars decorating the hours of night; other systems established in unknown profusion through the boundless dimensions of space; and even there we shall be only advanced to the suburbs of the creation, the frontiers of the great Creator's kingdom."

A VOCABULARY

OF

ASTRONOMICAL TERMS,

NAMES OF STARS, &c. &c.

AS THEY ARE USUALLY ACCENTED.

ACHE'RNAR, a star of the first magnitude in Eridanus.
Acro'nical, a term applied to any heavenly body when it is in opposition to the sun.
Acu'bens, a star marked *a* in Cancer.
Aldera'min, a star marked *a* in Cepheus.
A'dhil, a star of the sixth magnitude in Andromeda.
Alde'baran, a star of the first magnitude in Taurus.
Aldha'fera, a star of the third magnitude in Leo.
A'lgenib, a star of the second magnitude in Perseus.
A'lgol, a star of the second magnitude in Perseus.
Al'gorab, a star of the third magnitude in Corvus.
Al'kes, a star of the third magnitude in Crater et Hydra.
A'lioth, a star of the third magnitude in Ursa Major.
Almaca'ntars, are circles of altitude, parallel to the horizon.
A'lmaach, a star of the second magnitude in Andromeda.
Alphe'ratz, a star of the second magnitude in Andromeda.
A'ltitude, the altitude of any celestial body is its nearest distance to the horizon.

Alruccabah, the pole star; a star of the third magnitude in Ursa Minor.
Amphiscii, are the people who live in the torrid zone.
A'mplitude, is the point of the horizon at which a body rises from the east, and sets from the west.
Anale'mma, is a projection of the sphere on the plane of the meridian.
A'ngha, a star of the third magnitude in Aquarius.
Andro'meda, a northern constellation.
A'ngle, is the inclination of two lines meeting in a point.
Ano'maly, is the distance of a celestial body from its aphelion.
Anta'rctic Cir'cle, is the circle which bounds the south frigid zone.
Anta'res, a star of the first magnitude in Scorpio.
Antecede'ntia, the motion of a planet, contrary to the order of the signs.
Anti'podes, are people who live diametrically opposite one to an other.
Antœ'ci, are people who live in equal though opposite latitudes, under the same meridian.
Aphe'lion. A celestial body is in its aphelion when at the greatest distance from the body round which it revolves. This is called the higher Apsis.
A'pogee, is the point in the moon's orbit farthest from the earth.
Appa'rent Conjunction of two celestial bodies, is when they appear to us in the same degree of the zodiac.
Appa'rent Diam'eter of a celestial body, is the angle it forms to the eye of a spectator on the earth.
Appa'rent Horizon, is the circle which bounds our sight.
A'psis, a point in the orbit of a celestial body at its greatest or least distance from the body it is revolving round.
A'pis, a constellation of the southern hemisphere.
Aqua'rius, one of the zodiacal constellations.
Aqui'la, a northern constellation.
A ra, a southern constellation.
Arc, a portion of the circumference of a circle.
Arc'tic Circle, the circle which bounds the north frigid zone.

A'rcturus, a star of the first magnitude in Boötes.
Ar'go Na'vis, a southern constellation.
A'ries, the first zodiacal constellation.
Arie'tis, a star of the second magnitude in Aries.
Austra'lis, a southern constellation.
Asce'nsional Difference, is the difference between the right and oblique ascension, or descension.
A'scii, the inhabitants of the torrid zone.
As'pect, the situation of one heavenly body with respect to another.
Astero'ids, small planets between Mars and Jupiter.
Astro'logy, a *pretended* art of foretelling future events by the aspects of the planets.
Astro'nomy, a science which teaches the magnitudes, &c. &c. of the heavenly bodies.
Alta'ir, a star of the first magnitude in Aquila.
A'tmosphere, an invisible, elastic fluid, surrounding the earth, &c.
Attra'ction, the power with which one body or particle of matter, leads towards another.
Auri'ga, a northern constellation.
Auro'ra Borea'lis, meteors observed in the north.
Austra'lis, or Piscis Notius, a southern constellation.
A'xis, a line on which a body revolves.
A'zimuth, the bearing of any heavenly body from the meridian.
Be'llatrix, a star of the second magnitude in Orion.
Bete'lgeux, a star of the first magnitude in Orion.
Bi'ssextile, leap year, every fourth year.
Boötes, a northern constellation.
Ca'ncer, a zodiacal constellation.
Canis Major, a southern constellation.
Canis Minor, a northern constellation.
Canis Venatici, a northern constellation.
Canopus, a star of the first magnitude in Argo Navis.
Cape'lla, a star of the first magnitude in Auriga.
Ca'rdinal Points. East, west, north, and south, points of the horizon.
Cassio'peia, a northern constellation.
Ca'stor, a star of the first magnitude in Gemini.
Cele'stial globe, a globe representing the positions, magnitude, &c. of the stars.

Centa'urus, a southern constellation.
Centri'fugal force, is that force by which a body revolving round another endeavours to quit its curve.
Centri'petal force, is the force by which a body revolving round another, is drawn towards it.
Ce'res, an Asteroid, discovered by M. Piazzi.
Ce'tus, a southern constellation.
Cir'cle, a round figure: Circles are divided into great and small.
Cir'cle (Great,) is a circle which divides a globe into [two equal parts.
Cir'cle (Small,) is a circle which divides a globe into two unequal parts.
Colu'mba, a small southern constellation.
Colu'res, two circles passing through the poles and cutting the equator at right angles: one passes through the first point of Aries, and the first point of Libra, and is called the Equinoctial Colure; the other through the first point of Cancer and the first point of Capricorn, and is called the Solstitial Colure.
Co'ma Bere'nices, a northern constellation.
Com'et, a body in the solar system, with a shining tail.
Conju'nction of two celestial bodies, is their appearing in the same sign, &c. of the zodiac.
Conseque'ntia, the real motion of a heavenly body in the zodiac, called also direct.
Constella'tion, a number of stars which are imagined to form any particular animal, &c.
Cor Caro'li, a star of the second magnitude.
Cor Hy'dræ, a star of the second magnitude in Hydra.
Cor Leo'nis, a star of the first magnitude in Leo, called also Regulus.
Coro'na borea'lis, a beautiful northern constellation.
Coro'na meridiana'lis, a southern constellation.
Cos'mical rising and setting, is when a star rises and sets [at sun-rise.
Cor'vus, a southern constellation.
Cra'ter, a southern constellation.
Culmina'tion, the passage of a star over the meridian.
Cy'gnus, a northern constellation.
Day (artificial,) the time from sun-rising to sun-setting.
Day (astronomical or natural,) is the time elapsing between the sun's appearing twice on the same meridian.

Day (Side'real,) the time elapsing between a star's appearing twice on the same meridian.
Declina'tion, the distance of a celestial body from the Equinoctial.
Degre'e, the three hundred and sixtieth part of the circumference of every circle.
Delphi'nus, a northern constellation.
De'neb, a star of the second magnitude in Leo.
Depre'ssion, the distance of a body below the horizon.
Desce'nding Node, is the point where the orbit of a planet is imagined to cut the plane of the ecliptic, in going from a northern to a southern latitude.
Di'git, the twelfth part of the diameter of the sun or moon.
Disc, the face of the sun or moon.
Dra'co, a northern constellation.
Dub'he, a star of the second magnitude in Ursa Major.
Earth, the planet on which we reside.
East, one of the cardinal points of the horizon.
Eccentri'city, the distance of the sun from the centre of the elliptical orbit of a planet.
Ecli'pse, an obscuration of light from one body by the interposition of another.
Eclip'tic, the orbit the earth revolves in, in going round the sun.
Eleva'tion, the altitude of any object.
Elonga'tion, an angle formed by two imaginary lines; one drawn from the earth through the sun, and the other from the earth through the planet, continued to, and measured on the ecliptic.
Equation of time, is the difference between solar time, and mean or clock time.
Equinoxes, the beginning of Aries and Libra.
Equa'tor, a circle on the earth, equi-distant from each pole.
Equ'uleus, a northern constellation.
Equino'ctial, a circle in the heavens, corresponding to the equator on the earth.
Eri'danus, a southern constellation.
Fa'culæ, bright spots on the sun's disc.
Fo'cus. a point in the transverse diameter of an ellipse.

Fix'ed stars, stars whose position with regard to each other is fixed.
Fo'malhaut, a star of the first magnitude in Australis.
Gala'xy, the milky way.
Ge'mini, a zodiacal constellation.
Geoce'ntric place, the place of a celestial body as seen [from the earth.
Gi'bbous, the shape of the enlightened part of the moon, from first quarter to the full.
Ha'lo, a circle round the moon.
Hea'vens, the expanse in which the stars, sun, planets, [&c. are placed.
Heli'acal, a body rises or sets heliacally when it rises or sets with the sun.
Helioce'ntric place, the place of a celestial body as seen [from the sun.
He'misphere, the half of a sphere.
Her'cules, a northern constellation.
Her'schel, the last planet in the solar system.
Hetero'scii, inhabitants of the temperate zones.
Hori'zon, a great circle of the sphere, dividing the earth into two equal parts: its poles are the zenith and nadir.
Horizo'ntal, parallel to the horizon.
Horizo'ntal parallax, the parallax of a celestial body [when rising.
Hour, the twenty-fourth part of a natural day.
Hy'ades, a cluster of stars in Taurus.
Hy'dra, a southern constellation.
Hy'dra (Cor,) a star of the first magnitude in Hydra.
Hy'drus, a small southern constellation.
In'dus, a southern constellation.
In'gress, the sun's entering any particular sign.
Ju'no, the name of an asteroid.
Ju'piter, the largest of all the planets.
Ko'chab, a star of the second magnitude in Ursa Minor.
Lat'itude, the nearest distance of any place on the earth to the equator.
Lat'itude of a planet or star, is its nearest distance to the ecliptic.
Lace'rta, a northern constellation.
Leap year, every fourth year.
Le'o, a zodiacal constellation.
Le'o Mi'nor, a southern constellation.
Le'pus, a southern constellation.
Li'bra, a zodiacal constellation.

Libra'tion of the moon, an irregularity in the appearance of the moon's disc, whereby small portions of its surface at the northern and southern extremities, as well as the eastern and western, are alternately visible and invisible.

Line of the Ap'sides, a line joining the aphelion and perihelion of a planet.

Lin'es of longitude, meridians.

Lon'gitude of a celestial body, is an arch of the ecliptic, comprehended between the first point of Aries, and that point of the ecliptic intersected by a circle passing through its poles and that body; the longitude is reckoned eastward from Aries, and is expressed in signs, degrees, minutes, &c.

Longitude of a place, is an arch of the equator, comprehended between a first meridian, and the meridian of that place, expressed in degrees, minutes, &c.

Lu'pus, a southern constellation.

Ly'nx, a northern constellation.

Ly'ra, a northern constellation.

Mac'ulæ, dark spots on the sun's disc.

Mag'nitudes, the apparent sizes of the stars.

Mar'kab, a star of the second magnitude in Pegasus.

Mar'sic, a star of the second magnitude in Hercules.

Mars, the nearest superior planet.

Men'kar, a star of the second magnitude in Cetus.

Machi'na pneuma'tica, a southern constellation.

Mer'cury, the first and smallest of the planets.

Meri'dian, a circle passing through any particular place and the two poles.

Microsco'pium, a southern constellation.

Mid-heaven, is the point of the ecliptic upon any particular meridian at a given time.

Mi'lky-way, is a circular luminous zone of whitish light, and various breadth, encompassing the heavens. Its soft cloudy appearance, is effected by the united lustre of innumerable stars in that direction, invisible by reason of their immeasurable distance.

Min'ute, the 60th part of an hour, or degree.

Mi'rach, a star of the second magnitude in Andromeda.

Mono'ceros, a northern constellation.

Mons me'nsæ, a southern constellation.

Month, the twelfth part of a year.
Mons Mœ'nalus, a northern constellation.
Moon, the satellite of the earth.
Mus'ca, a northern constellation.
Musca Austra'lis, a southern constellation.
Nadir, the opposite of zenith; one of the poles of the horizon.
Nebulæ, telescopic stars, appearing cloudy.
Noctu'rnal Arc, the arc described by a celestial body from its setting to its rising.
Nonage'simal Degree, the highest point of the ecliptic above the horizon, eqnal to the angle the ecliptic makes with the horizon.
Nodes, the point where a planet's orbit is imagined to cut the ecliptic.
Noon (Apparent,) the time the sun is on the meridian; 12 o'clock.
Noon (True,) the time shown by a well regulated clock.
North, a cardinal point of the horizon.
Norma, (or Quadra Euclidis), a southern constellation.
Nuta'tion of the axis of the earth, a libratory motion, by which the obliquity of the ecliptic is effected.
Obli'que Asce'nsion, the point of the equinoctial which rises with the sun, or star, &c. [moon.
Occulta'tion, the obscuration of a celestial body by the
Obli'quity of the Ecliptic, the angle the plane of the earth's orbit makes with the equator; this in 1821 was 23° 27′ 57″.
Opposi'tion, the aspect of two celestial bodies when they are six signs distant.
Ol'bers, (see Pallas.) [an other.
Orbit, the curve one body describes in revolving round
O'rion, a brilliant and conspicuous constellation during our winter months.
Offici'na Sculptoria, a southern constellation.
Pa'llas, the name of an Asteroid.
Parallax, the angle the semi-diameter of the earth forms with a celestial body.
Pa'rallels of Latitude, small circles on the celestial globe parallel to the ecliptic.
Pa'rallels of Declination, small circles on the celestial globe parallel to the equinoctial.

Par'allel sphere, is that position of the sphere, in which the equator coincides with the horizon.
Pa'vo, a southern constellation.
Pe'gasus, a northern constellation.
Penu'mbra, a faint shade surrounding the perfect shadow in an eclipse.
Pe'rigee, the point in the moon's orbit nearest to the [earth.
Perihe'lion, the point in a planet's orbit nearest to the sun.
Perice'ci, those who live in the same latitude, but on [the opposite meridian.
Peri'scii, the inhabitants of the frigid zones, so called because their shadows are turned in every direction in 24 hours.
Pe'rseus, a northern constellation.
Pha'ses, the different appearances of the enlightened part of the moon, or inferior planets.
Phœ'nix, a southern constellation.
Pi'sces, a zodiacal constellation.
Piscis No'tus, a southern constellation.
Pla'net, a celestial body which revolves round the sun.
Ple'iades, the seven stars, a prominent cluster of stars in Taurus.
Po'inters, two stars in Ursa Major, which always point to the pole-star.
Poles, the extremities of the axis of a body.
Pole Star, a star of the second magnitude in Ursa Minor, near the northern point of the heavens.
Po'llux, a star of the second magnitude in Gemini.
Praxi'teles, a southern constellation.
Prece'ssion of the Equinoxes, a slow motion of the equinoxes antecedentia around the ecliptic.
Pri'mary Planets, bodies which revolve round the sun as a centre.
Pro'cyon, a star of the first magnitude in Canis Minor.
Qua'drant, the quarter of a circle; a mathematical instrument. [from the sun.
Qua'drature, the position of the moon, when three signs
Quartile aspect; marked □, the position of two celestial bodies when three signs distant.
Ras Alge'thi, a star of the third magnitude in Hercules.
Ras Alha'gus, a star of the second magnitude in Serpentarius.

Rasta'ben, a star of the second magnitude in Draco.
Ra'dius, the half of the diameter of a circle.
Refra'ction, the bending of the rays of light, in passing from a rarer to a denser medium.
Re'gulus, a star of the first magnitude in Leo.
Re'trograde, the same as antecedentia.
Revolu'tion, the period of a celestial body.
Ri'gel, a star of the first magnitude in Orion.
Right Asce'nsion, the point of the equinoctial which comes to the meridian with any celestial body.
Sagi'tta, a northern constellation.
Sagitta'rius, a zodaical constellation.
Sa'ros, Chaldean Saros, the space of 18 years, 11 days, 7 hours, 43 minutes, 20 seconds; the time in which eclipses exactly return.
Sa'tellites, secondary planets or moons, revolving round the primary planets.
Saturn, a superior planet, having seven satellites.
Scheat, a star of the second magnitude in Pagasus.
Schedar, a star of the third magnitude in Cassiopeia.
Scorpio, a zodiacal constellation.
Scutum Sobieski, a northern constellation.
Second, the 60th part of a minute.
Serpens, a northern constellation.
Serpenta'rius, a northern constellation.
Se'xtant, a mathematical instrument; the sixth part of a circle.
Sextans, a southern constellation.
Sextile Aspect, the position of two celestial bodies when they are two signs distant.
Side'real Day, the time which elapses between a star's appearing twice on the same meridian; it is 23 hrs. 56' 4".1.
Sidereal Year, the time which elapses between the sun's appearing twice in conjunction with the same star.
Sign, the twelfth part of the ecliptic; 30°.
Si'rius, the brightest star in the heavens, situated in Canis Major.
Situ'la, a star of the third magnitude in Aquarius.
So'lstices, the time the sun enters Cancer and Capricorn.
South, a cardinal point in the horizon.

Sphere, a globe.
Spi'ca, a star of the first magnitude in Virgo.
Sta'tionary, the position of a heavenly body, when it appears to remain at one place for some time.
Sun, the grand luminary of day.
Sy'zygies, the conjunction and opposition of a planet with the sun.
Tangent, a line touching a circle, perpendicular to the radius which connects it with the centre.
Taurus, a zodiacal constellation.
Te'rminator, an imaginary line which divides the light hemisphere from the dark.
Tides, the rising and falling of the waters of the ocean.
Time, the measure of duration, depending on the revolution of the celestial bodies.
To'ucan, a southern constellation.
Transit, the passing of an inferior planet over the sun's disc.
Tropics, two circles bounding the torrid zone.
Twilight, the faint light before sun-rising and after sun-setting.
Taurus Poniato'wski, a northern constellation.
Tri'angulum, a northern constellation, near Arietis.
Tri'angulum Mi'nus, a northern constellation.
Tri'angulum Austra'le, a southern constellation.
Telesco'pium, a southern constellation.
Va'ria, a star of the third magnitude in Aquila.
Ve'ga, a star of the first magnitude in Lyra.
Ve'nus, the brightest of the planets.
Ver'ticle Circles, imaginary circles, passing through the Zenith and Nadir.
Ves'ta, one of the asteroids.
Vi'a La'ctea, the milky way.
Vindemi'atrix, a star of the third magnitude in Virgo.
Vi'rgo, a zodiacal constellation.
Umbra, the conical shadow of the earth or moon in an eclipse.
Vulp'ecula et A'nser, a northern constellation.
Ura'nus, a name some times given to the planet Herschel.
Ursa Major, a very conspicuous northern constellation.

Ur'sa Mi'nor, a northern constellation, in which the pole star is situated.
Xi'phias, a southern constellation.
Year (a solar,) the space of 365 days, 5 hrs. 48′ 48″.
Year (a sidereal,) the space of 365 days, 6 hours, 9′ 12″.
Zen'ith, the point exactly over head; one of the poles of the horizon.
Zo'diac, the space in which all the planets move in revolving round the sun.
Zone, a division of the earth: there are five zones.
Zubenelg, a star of the second magnitude in Libra.
Zubenesch, a star of the second magnitude in Libra.
Zub'enna, Kra'bi, a star of the second magnitude in Libra.

THE END.

QUESTIONS

ON

TREEBY'S ELEMENTS

OF

ASTRONOMY.

BY S. TREEBY.

PREFACE.

It is quite superfluous to attempt to state the advantages attending the interrogatory system of education: its universal adoption is an unanswerable argument of its utility: but while geography, history, and the belles-lettres, are cultivated in seminaries by the fertilizing hands of interrogatories, the most noble of all sciences has hitherto been left wildly to shoot, without the assistance of any guide excepting nature. The present book of questions is founded on a work which has long been found wanting in English schools; and is, for conveniency's sake, divided into four parts; the first comprises about five hundred Questions on the numbered articles in Part I. of *The Elements of Astronomy:* and as they bear immediately on the facts interspersed therein, they require no other assistants to develope their answers, than an attentive perusal of that portion of the work. They are intentionally

irregularly arranged, which arrangement is a manifest advantage, inasmuch as it tends to quicken the memory, and to mature the understanding of the learner. The second part contains nearly Eighty Questions on the observations which succeed the numbered articles as illustrations, deductions, inferences, proofs, &c. in that part of the work: among which may be found clearly illustrated, the methods astronomers have had recourse to for ascertaining the magnitudes, periods, distances, &c. of the planetary bodies, by which they have determined the times they revolve on their axes, their elliptical orbits, the nature and causes of their accelerated and retrograde motions, and their stationary appearances; how the longitude of places on the earth may be found by means of the eclipses of the moon, the satellites of Jupiter, or by the culmination of the fixed stars; proofs of the rotundity of the earth; an easy method of calculating the return of eclipses, &c.; which observations requiring more judgment to be understood, than the facts which are numbered, questions on them will consequently serve as criterions for determining whether the pupil's understanding keeps pace with his memory, and

may therefore be used according to the discretion of the intelligent teacher.

The third part includes nearly sixty Questions on "The Planetary Problems" in Part II. of the *The Elements:* these, as well as the others are irregularly arranged, and will therefore, more completely answer their design. The fourth and last part comprises questions on "The Problems on the Globes:" amongst them are several on the Geographical and Astronomical Definitions, &c. in Part III. of "*The Elements:*" these will be found to be inferior to none extant for the purposes of examining the pupil in that department of ornamental, instructive, pleasing, and useful literature.

Plymouth. Dec. 12, 1821.

PART I.

QUESTIONS

BEARING DIRECTLY ON THE FACTS

IN THE

ELEMENTS OF ASTRONOMY:

To be answered by the Student in writing.

1. WHICH of the planets have satellites?
2. What is the longitude of a planet?
3. What are secondary planets?
4. What is astronomy?
5. What is the office of a secondary planet?
6. Upon what is physical astronomy founded?
7. How many planets are there in the solar system?
8. What is meant by the length of a planet's day?
9. How long does Mercury take to revolve on its axis?
10. Have the inhabitants of Venus any morning and evening star?
11. How are the solar spots divided?
12. What is meant by the orbit of any celestial body?
13. How many kinds of motions have the planets?
14. How do you determine the earth and the Sun's places in the ecliptic?
15. What are the solstitial days?
16. What is meant by the sun's declination?
17. Does Mercury ever transit the Sun?
18. How many signs are in the ecliptic? name them.

19. What proportion is there between the specific gravities of water and air?
20. In what sign does the planet Venus intersect the plane of the ecliptic?
21 What body is in the centre of the solar system?
22. What is meant by the direct motion of a planet?
23. What is meant by the diurnal and nocturnal arcs of the sun, a planet, or star?
24. In what part of its orbit was the comet of 1819, when visible to us?
25. How is snow occasioned?
26. What is Venus poetically called when she is an evening star?
27. What is meant by a planet's orbicular motion?
28. In what direction is the motion of the earth?
29. How long is the solar day?
30. How long is a solar year?
31. How long does the earth take to revolve from any particular portion of the ecliptic, until it arrives there again?
32. What are primary planets?
33. How far does the zodiac extend on each side of the ecliptic?
34. When is the sun's declination the greatest?
35. What are the tropics?
36. What are clouds?
37. What is a lunation?
38. What is a parallax?
39. What is the diameter of Jupiter?
40. What effects have heat and cold upon our atmosphere?
41. When is the earth in the equinoxes?
42. How long is a solar year; and which is the longer part, the summer or the winter?
43. What is Jupiter's ascending node?
44. What did the ancient's consider the sun to be?
45. What is the difference between a planet and a comet?
46. What is the axis of a celestial body?
47. Is the earth nearer to the sun in the winter or in the summer?
48. What is hail?

49. Who discovered the planet Herschel?
50. In what part of the ecliptic is the ascending node of Saturn?
51. Why was the name of Mercury given to that planet which is nearest to the sun?
52. What is a planet?
53. How long is Saturn revolving round the sun?
54. What is a comet, and how long was the tail of the comet of 1819?
55. What are falling stars?
56. At what time of the day shall we be likely to see the planet Mercury?
57. How long is Mars revolving round the sun?
58. How are planets divided?
59. How are the different seasons occasioned?
60. What is lightning?
61. By what character is Saturn expressed?
62. What is a mist or fog.
63. What kind of curve do the planets describe in revolving round the sun?
64. What effects are produced by the inclination of the axis of the earth?
65. What is a central eclipse?
66. Which is the longest day in the year in a southern latitude?
67. What are the two extreme points of the axis of a body called?
68. What appearance has Saturn to the naked eye?
69. How long does Jupiter take to revolve on its axis?
70. On what days is the declination of the sun nothing?
71. Define the equator.
72. How long does the earth require to revolve on its axis?
73. What is the name of that circle called which bounds the North Frigid Zone?
74. What are the effects of the rotation of the earth on its axis?
75. How far over the north pole do the Sun's rays extend on the longest day, or June 21st.
76. What star is it that always appears in the same position nearly?

77. What is meant by the conjunction of two celestial bodies?
78. Are the solar days always of the same length?
79. When has the sun no declination?
80. What is thunder?
81. How far distant is Herschel?
82. What is the name of the line about which the earth seems to revolve?
83. What is meant by a planet's daily motion?
84. How many satellites are there in the solar system?
85. How is Astronomy divided?
86. What is meant by the heliocentric longitude of a planet?
87. Into how many degrees is the circumference of the earth divided?
88. Are the dews heavier in hot or in cold countries?
89. How far distant is Mars from the sun?
90. What is an occultation?
91. Repeat Pope's description of the moon.
92. What is the ecliptic?
93. What do modern astronomers consider the sun to be?
94. What is a partial eclipse?
95. Into how many kinds are conjunctions divided?
96. Which planets have an inferior and superior conjunction?
97. What is meant by the stationary appearance of a planet?
98. When Venus is a morning star is she to the east or to the west of the sun?
99. What is the reason that the fifth planet in the solar lar system is named Jupiter?
100. What is the diameter of Mars?
101. How are the celestial bodies divided?
102. What is meant by the precession of the equinoxes?
103. What is physical astronomy?
104. Name the zodiacal constellations.
105 What is the greatest elongation of Mercury?
106. By what is the earth attended in its motion round the sun?
107. Of what does the solar system consist?

108. Who first discovered the phases of Venus?
109. What is the quantity and direction of the precession of the equinoxes?
110. How long does the earth take to revolve around the sun?
111. What clouds generally produce rain?
112. How is it, that the moon at her opposition appears entirely enlightened?
113. What is understood by the meridian of any particular place?
114. What effects are produced, when the clouds which produce lightning are very low?
115. How far are the asteroids distant from the sun?
116. What is the ecliptic?
117. What is the elongation of a planet?
118. What is the probable causes of the changes of weather, at the new and full moon?
119. What is the twilight?
120. How is Venus poetically described by Baker?
121. What is the horison of any particular place?
122. Of what does the universe consist?
123. What is meant by the opposition of the celestial bodies?
124. How many comets have already been observed?
125. At what part of the day does the sun appear on the meridian of any particular place?
126. What are the polar circles?
127. What is a temperate zone?
128. When is a planet said to move in a retrograde direction?
129. Does Venus ever transit the sun?
130. How is dew generated?
131. How many stars are discernible in a clear evening? [ets?
132. Which in appearance is the darkest of the plan-
133. How long are the asteroids in revolving round
134. What is pure astronomy? [the sun?
135. How long is the planet Herschel in revolving round the sun?
136. What is the shape of the earth?
137. When Mercury transits the sun, what appearance has it on the sun's disc?

138. On what days is the earth in the equinoctial points?
139. What is the general reservoir of dews?
140. What are the belts of Jupiter considered to be?
141. How are the planets divided?
142. How long was the tail of the comet of 1680?
143. How long does Venus take to revolve round the sun? [ed?
144. With what is the surface of the moon interspers-
145. Which is the least planet in the solar system?
146. Where is Jupiter's descending node?
147. Are the Asteroids visible to the naked eye?
148. What is the diameter of Herschel?
149. How is pure astronomy determined?
150. What is the source of rain and dews?
151. When will the next transit of Venus be?
152. Has Jupiter any spots on his surface?
153. Do the stars shine by reason of the Sun's light?
154. Which planets have both an inferior and superior conjunction?
155. When does the retrograde motion of an inferior planet happen? [cancer?
156. On which side of the equator is the tropic of
157. What is meant by the obliquity of the ecliptic?
158. How far distant is Mercury from the Sun?
159. What is the Zodiac?
160. By what character is Jupiter distinguished?
161. What is meant by the harvest moon?
162. What is solar time?
. 163. Would a bowl upon a hill, or upon the surface of the earth, receive the greater quantity of water during the same shower?
164. When was the planet Herschel discovered?
165. How many satellites has Saturn?
166 Does the dew descend the more copiously upon the earth after a hot or a cold day: and why?
167. What parts of the ecliptic are called solstitial points?
168. By what character is Mercury distinguished?
169. Into what are the bodies which revolve round the Sun divided?
170. What is meant by a planet's heliocentric place?

171. Why is the particular situations of the sun, planets, comets, &c. with respect to each other, called the *solar* system?

172. To what are the diversified colours of the clouds owing?

173. In what city was it that the celebrated astronomer Herschell discovered the planet which bears his name?

174. How long is Saturn revolving on its axis?

175. In what position is the axis of the earth with respect to the plane of the ecliptic?

176. What appearances have the mountains, islands, &c. of the earth, to the inhabitants of the moon?

177. What is the size of the earth?

178. How does Thomson beautifully describe the sun?

179. How many asteroids are there in the solar system?

180. What is meant by the horizontal parallax of a celestial body?

181. What does an annular eclipse mean?

182. What are tides?

183. By what characters are the planets distinguished?

184. To what are the various shapes of clouds owing?

185. How are the inhabitants of Jupiter compensated for their defect of the light of the sun?

186. How many temperate zones are there?

187. By what is the earth surrounded?

188. What angle does the orbit of Mars make with the plane of the ecliptic?

189. How do astronomers prove the ring of Saturn to be a solid body surrounding that planet?

190. How many kinds of motion is the earth endued with?

191. What effects are produced by the rotation of a secondary planet on its axis?

192. Between which two planets is Venus situated?

193. How have astronomers determined the height of the mountains of the moon?

194. Which is the third planet in the solar system?

195. Where does the orbit of Mercury appear to cut the plate of the ecliptic?

196. How is it that the sun, which is stationary, appears to rise, attain its meridian splendor, and set?

197. What is the difference between a solar and a sidereal day?
198. What is the greatest elongation of Venus?
199. What is the office of the moon?
200. What are clouds?
201. What kind of curve do comets describe in revolving around the sun?
202. Are the clouds all of one height?
203. What is the length of time the earth is revolving around the sun called?
204. Which planet mostly resembles the earth?
205. How long is the moon in revolving from one fixed star, before it returns to it again?
206. What is the circle called which bounds the South Frigid Zone?
207. How do you prove that the revolution of the earth on its axis, is from west to east?
208. How do you determine the space the earth proceeds in its orbit, during one revolution on its axis?
209. What proportion of light and heat does Jupiter receive, compared to that which invigorates the earth?
210. What character is used to distinguish the planet Herschell?
211. How is the apparent motion of the stars occasioned?
212. What is a total eclipse? [eye?
213. How large is the planet Herschell to the naked
214. Why must eclipses of the sun happen at new moon? [tain?
215. What does the middle section of the earth con-
216. Is the motion of the earth in the ecliptic uniformly equal, in two equal measures of mean time?
217. Of what use is the atmosphere to us?
218. What are the names of those points where the orbit of Mercury is imagined to intersect the ecliptic?
219. What are inferior planets; and why are any so called?
220. Which is the nearest of the superior planets?
221. What is meant by a planet's retrograde motion?
222. In what parts of the ecliptic are the equinoctial points placed?
223. How often do the tides rise?

224. What composed the body of the telescope, with which Galileo discovered the satellites of Jupiter?

225. How large is the sun, & how large is the moon?

226. What proportion has the sun to the moon in raising the tides?

227. What is remarkable of the atmosphere of the sun?

228. Are the drops of rain larger or smaller at the surface of the earth, or when they first descend from the clouds?

229. How long would the night be to the inhabitants of Jupiter, if his axis were much inclined?

230 With what force does the atmosphere press upon the earth?

231. How long was the tail of the comet of 1811?

232. What reason can be assigned for the stars appearing so very numerous?

233. What is the aurora borealis?

234. What is the reason that the summer half year is longer than the winter?

235. Which are the superior planets; and why are they so called?

236. What is remarkable of the belts of Jupiter?

237. Does the sun move around the earth as was formerly supposed, or does the earth move around the sun?

238. When Venus is a morning star, what is she poetically called?

239. How would the sun appear if there were no atmosphere surrounding the earth?

240. Which are the principal constellations?

241. What is meant by the geocentric longitude of a planet?

242. Which of the planets shines so brilliantly as to cause objects which it illuminates to cast a shadow?

243. Which is the only body in the solar system that shines by its own light?

244. How do you know that the earth is nearer to the sun in the winter than it is in the summer?

245. Which is the most brilliant of the planets?

246. What is the greatest height to which clouds ascend?

247. Why is the natural day called a solar day?

248. How is the atmosphere essential in rarefying the noxious effluvia which arise from the earth?

249. Which was anciently considered the most distant planet in the solar system?
250. How many stars did the astronomer Herschell count in a small portion of the milky way?
251. What is meant by a sextile aspect?
252. Where is the planet Saturn's descending node?
253. What does an inferior conjunction mean?
254. What advantages are derived to astronomy by the satellites of Jupiter?
255. What is a synodical month?
256. How long is the sun revolving on its axis?
257. Is Mercury a primary or a secondary planet?
258. What is the distance of the earth from the sun?
259. How may I know when any planet is in opposition to the sun?
260. What is meant by a planet's apparent place?
261. How far is Venus distant from the sun?
262. The day and night is unequally divided throughout the year, excepting two days; which are they?
263. How is the progressive motion of light proved?
264. How is the length of the sidereal day determined?
265. On which side of the equator is the tropic of Capricorn?
266. What is the greatest portion of the earth the sun does not shine on in a day?
267 What is meant by the parallax of the earth's annual orbit?
268. Why do eclipses happen irregularly?
269. When a planet is in opposition to the sun, how far is its place from the earth's place, and how far from the sun's?
270. Which are the more frequent, eclipses of the sun, or of the moon?
271. Why does the Pole Star appear appear to be always in the same position?
272. What is the reason that Venus is never visible at midnight?
273. What is the most general height of the clouds?
274. Are the satellites of Jupiter discernible by the naked eye?
275. What is remarkable in the periodic times of the comets?

276. How does the firmament appear when viewed through a telescope?
277. When have any two celestial bodies a trine aspect?
278. How is it that an eclipse of the moon is visible to every place where she is visible?
279. What did Sir Isaac Newton say the tails of comets were?
280 How far does the atmosphere of the earth extend from its surface?
281. Is the atmosphere denser or rarer in the upper regions?
282 How is the solid body of the earth divided?
283. What is a sidereal day?
284. Of what nature are the stars supposed to be?
285. What is the milky way?
286. What is meant by one planet's having a quartile aspect with regard to another?
287. What is a superior conjunction?
288. In what direction is the axis of Jupiter compared with the plane of the ecliptic?
289. Who had the honour of discovering the satellites of Saturn?
290. What is the ring of Saturn?
291. Into how many zones is the earth divided?
292. How long does Venus take to revolve on her axis?
293. What is the exact period that Mercury takes to revolve around the sun?
294. How many signs is the geocentric from the heliocentic place of a planet, when such planet is in an inferior conjunction? [duce?
295. What does the external section of the earth pro-
296. What is the greatest number of eclipses that can happen in a year?
297. How long is the sidereal day?
298. What is the comparative lengths of the days on the earth and at the moon?
299. How many asteroids are there, and by whom were they so named?
300. What is meant by the parallax of a celestial body?
301. What other name is given to the planet Herschell? and why?

302. How much denser is the atmosphere of the sun, than the atmosphere of the earth?

303. How far does the zodiac extend from the plane of the ecliptic?

304. When does the retrograde motion of a superior planet happen?

305. What is the elevation of the pole above the horizon equal to?

306. In what direction do the moon's nodes move?

307. What is remarkable of the solar spots?

308. What is the nearest distance of any celestial body to the ecliptic called?

309. What is the least number of eclipses that can happen in a year?

310. What is meant by a planet's retrograde motion?

311. How is the Zodiac divided?

312. In what part of her orbit is the moon, when she is eclipsed?

313. How long is the moon revolving on her axis?

314. What is meant by the equation of time?

315. By what means do we derive light from the sun before he rises, and after he sets?

316. How long is Mars revolving on its axis?

317. If a body weigh a pound on the surface of the earth, what would it weigh if it were removed to the surface of the moon?

318. Suppose the moon's orbit were situated in the plane of the ecliptic, how often would eclipses happen?

319. To what is the red appearance of Mars owing?

320 Within what distance of the horizon is the sun, when twilight commences in the morning, and ends in the evening?

321. Of what is the internal section of the earth composed?

322 By whom were the solar spots first discovered?

323. Mark the characters used to distinguish the constellations of the Zodiac.

324. What is a frigid zone?

325. Do the rays of the sun ever enlighten both the poles of the earth at the same time?

326. What is a total eclipse?

327. How many constellations are there north of the Zodiac?

328. How long was the Astronomer Herschell counting 116,000 stars?

329. How long can a lunar eclipse continue?

330. How is an eclipse of the sun occasioned?

331. What are those different points of the ecliptic called, where the orbits of the planets seem to cut its plane?

332. Which is the first planet in the solar system?

333. Why is Mercury called an inferior planet?

334. How many frigid zones are there?

335. What is a day?

336. How long does Jupiter take to revolve around the sun?

337. Why are there more visible eclipses of the moon than of the sun, at any particular place?

338. Which planet, when viewed through a telescope, has phases like the moon?

339. Why is the orbit of the earth called the ecliptic?

340. What is meant by the declination of the sun?

341. How far does the torrid zone extend?

342. What is an hour?

343. What is the distance of the moon from the earth?

344. What character is used to represent Mars?

345. How far distant is Jupiter from the sun?

346. When Jupiter is in opposition to the sun, how far is he from the earth?

347. When Jupiter is in conjunction with the sun, how far is he from the earth?

348. What angle does the axis of Mars make with a perpendicular to the plane of its orbit?

349. What advantage, besides proving the progressive motion of light, do we derive from the discovery of the satellites of Jupiter?

350. Why must the moon be in one of her nodes to eclipse the sun?

351. How long can the moon be totally eclipsed?

352. How is the ascending node of a planet marked?

353. Which planet revolves around the sun in the shortest space of time?

354. How long does Venus continue a morning and an evening star alternately?
355. How does the poet Baker describe Mercury?
356. What is a solar day?
357. Which is the most resplendent body in the heavens, next to the sun?
358. In what direction does the moon revolve around the earth?
359. What are the bright spots near the poles of Mars considered to be?
360. What is meant by the term digit?
361. What is the diameter of Mercury?
362. How is the descending node of a planet marked?
363. What is the torrid zone?
364. How many kinds of days are there?
365. What is mean time?
366. How long is the moon making a complete revolution around the earth?
367. Why is the fourth planet in the solar system called Mars?
268. How many satellites has the planet Hesrschell?
369. Between which planets are the asteroids?
370. What particular advantages result to astronomy from the various aspects of the planets?
371. Is Mercury an inferior or superior planet?
372. What is Venus called when she appears in the morning, and what when she is visible in the evening?
373. What is meant by the sun's path in the heavens?
374. On what part of the earth are the days and nights always equal?
375. Is Venus a superior or an inferior planet?
376. In what portion of her orbit is the earth, when the day is equal to the night all over its surface?
377. What are the boundaries of the torrid zone called?
378. What other names are given to the solar day?
379. What kind of a body is the moon?
380. How many aspects have astronomers divided the configuration of the celestial bodies into?
381. How is the retrograde motion of an inferior planet occasioned?
382. What kind of motion do the stars appear to have?

383. How are the phases of the moon occasioned?
384. In what direction do the moon's nodes move?
385. Which planet is the farthest from the sun?
386. How many satellites has Saturn?
387. How many constellations are there?
388. Name the principal stars visible in our winter evenings.
389. What curve does the moon describe in revolving around the earth?
390. Which is the fifth planet in the solar system?
391 Where is the ascending node of Mars?
392. Which is the brightest of the stars, and in what constellation is it?
393. It what degree are the stars magnified, when viewed through a telescope?
394. What is the moon's mean motion in a day?
395. What proportion is there between the densities of the atmospheres of the earth and moon?
396. Which is the largest planet in the solar system?
397. How do astronomers determine the distance of Mars?
398. What letter do the principal stars in the constellation Cassiopeia represent?
399. Between which planets is Jupiter?
400. In which of the constellations are the Pleiades?
401. Why is Jupiter called a morning and an evening star?
402. In what portion of her orbit is the moon when she appears semicircular?
403. How many degrees do the moon's nodes move in a year?
404. Has the moon any atmosphere?
405. How do you know that Mars is farther from the sun than the earth is?
406. Who first determined the time that Mars is revolving on its axis?
407 What is the surface of Jupiter interspersed with?
408. Has Saturn any spots on its surface?
409. Who first discovered the ring of Saturn?
410. In what proportion are the planets magnified when viewed through a telescope?

411. How large was the comet of 1811?
412. How are the tides occasioned?
413. What kind of bodies were comets formerly considered to be?
414. What is the greatest distance that Saturn can be from the plane of the ecliptic?
415. Which is the least splendid of the planets?
416. From the conjunction to the opposition of the moon, is the enlightened part of her circumference towards the east or west?
417. Of what practical utility are the occultations of the planets or stars?
418. How is the character for conjunction made?
419. What is a periodical month?
420. How old is the moon when she sets at sun rising?
421. Why are the tides higher at new and full moons than at other times?
422. Which are the principal northern constellations?
423. What is an eclipse?
424. Observing the moon, I perceived she was semicircular and her enlightened edge was towards the east; how old was she?
425. What angle does the orbit of the moon make with the plane of the ecliptic?
426. When eclipses of the sun happen, of what age is the moon?
427. What is meant by a planet's real, or direct motion or place?
428. What uses were the observations of the aspects of the planets applied to by astrologers?
429. What is meant by the moon's nodes?
430. Which is the fourth planet in the solar system?
431. What is the horizontal moon?
432. What is the period of Jupiter?
433. How is the retrograde motion of a superior planet occasioned?
434. How do the planets move around the sun?
435. What is meant by the stationary appearance of a planet?
436. How is an eclipse of the moon occasioned?
437. Do eclipses of the sun appear to all places on the earth where the sun is visible at the same time?

438. Can astronomers determine the distances of the stars?

439. How many stars are there of the first, second, third, fourth, fifth, and sixth magnitudes, respectively?

440. How many southern constellations are there?

441. For what purpose were the stars divided into constellations?

442. Why can not astronomers tell the distances of the stars, as well as the distances of the sun, moon, or planets?

443. What effect is produced by a light shining on a dark body?

444. How many inferior planets will an inhabitant of Mars have?

445. What has been observed near the poles of Mars?

446. How is it that the moon, which is one of the least of the heavenly bodies, appears one of the largest?

447. What angle does the axis of the moon make with a perpendicular to the plane of the ecliptic?

448. Which is the brightest planet to the inhabitants of Mars?

449. In what part of her orbit is the moon at the time of new moon?

450. Which of the planets, besides Jupiter, has belts?

451. How old is the moon when she appears on the meridian at midnight?

452. What did Sir I. Newton say comets were?

453. What is the length of the longest day to the inhabitants of Jupiter?

454. By what is Saturn circumscribed?

455. What is the difference between a periodical and a synodical month?

456. How many satellites has Jupiter?

457. What is the distance of Saturn?

458. Who first ranked comets among the bodies of the solar system?

459. What is the diameter of Saturn?

460. What are the changes in the appearances of the moon called?

461. What other bodies besides planets and asteroids, belong to the solar system?

462. What are Syzygies?

463. What is meant by the conjunction of the sun and moon?

464. When is the moon said to be in conjunction?

465. Do comets go very near the sun?

466. In what part of her orbit is the moon when nearest the sun?

467. How far distant was the comet of 1811, when nearest to the earth?

468. In what part of her orbit is the moon at full moon?

469. What did Sir Isaac Newton say respecting the heat of the comet of 1680?

470. When is the moon in that part of her orbit which is farthest from the sun?

471. How long did Sir Isaac Newton say the comet of 1680 would require to get cold?

472. How many kinds of eclipses are there?

473. What figure will be generated by the rays of a larger luminous body shining on a smaller opaque globular one?

474. What portion of her orbit must the moon be in to eclipse the sun?

475. How is it that the moon is invisible to us at the time of her conjunction?

476. Is it at new or full moon that the moon rises at sun-set?

477. What is the precession of the equinoxes?

478. By what power are the celestial bodies preserved in their orbits?

479. How many days have the inhabitants of the moon in a year?

480. How many comets have already been observed?

481. In what direction do the equinoxes move, and how many seconds in a year is that motion?

482. Of what shape are the orbits of all the planetary bodies?

483. What is the foundation of all motion?

484. How many stars is the firmament imagined to contain?

485. What is the first division of time?

486. How are the fixed stars distinguished from the planets?

487. What is meant by the term year; and how long is the year respectively at each of the planets?

488. What is the reason that the distances and periods of comets can not be determined, as well as the distances, periods, &c. of the planets?

489. By whom was the power of gravitation first proved to exist?

490. In what direction does the moon revolve on her axis?

491. How long is a day at the moon, compared with a day on the earth?

492. What is time?

493. By what power are the celestial bodies preserved in their respective orbits?

494. The inhabitants of which planet have the shortest days?

495. What is the difference in the appearances of the planets and stars, when viewed through a telescope?

496. What bodies are imagined to be continually revolving around every fixed star?

497. What is the difference between an occultation and a transit?

498. On what day does the earth enter ♎?

499. Which of the celestial bodies has the greatest parallax, and why?

PART II.

QUESTIONS

BEARING ON THE OBSERVATIONS.

To be answered by the Student in writing.

500. How is the circumference of every circle divided?

501. Prove to me by a diagram, that it is not possible to see an inferior planet in the night.

502. How do astronomers determine the distance the earth is from the sun?

503. How do you explain the inequalities in the lengths of the solar days?

504. Illustrate the variation in the declination of the sun?

505. How long would light be travelling from us to the nearest fixed star?

506. How do you determine the time the moon is revolving on its axis?

507. Tell me the causes of the variations in the seasons.

508. What curve does each planet describe in revolving around the sun?

509. How do you illustrate the apparent diurnal motion of the sun, by a person sailing in a boat?

510 In what part of the ellipse described by a planet, is the sun placed?

511. When do the highest and lowest tides happen?

512. What is the reason that a synodical is longer than a periodical month?

513. How is the time determined which the earth takes to revolve around the sun?

514. Why do you imagine the sun, moon, and planets to be inhabited?

515. How do you prove that the planets revolve around the sun, and not around the earth?

516. How is the time the sun is revolving on its axis determined?

517. Of what use is the horizontal parallax in astronomical calculations?

518. What is meant by the sun's apparent diameter?

519. How do eclipses of the moon prove the earth to be circular?

520. By whom were the spots on the sun's disc first discovered?

521. Is the parallax of a celestial body affected by its distance?

522. How may eclipses for any particular year be readily calculated?

523. Explain the nature of eclipses by a diagram.

524. Are tides generated in lakes?

525. How do you prove that the motion of the earth around the sun, is from west to east?

526. How do you prove that light is progressive in its motion?

527. How long would a cannon ball be in going to the nearest fixed star, if it were to continue with the same velocity as when first projected?

528. How may we know when to expect a solar or lunar eclipse?

529. Illustrate the nature of a parallax.

530. Illustrate the causes of the opposition and the conjunction of the superior planets.

531. Illustrate the causes of the inferior and superior conjunctions of the inferior planets?

532. What kind of appearance does the earth present to the moon?

533. How do you determine the distances of the superior planets, exclusively by their parallax?

534. How are lunar eclipses useful in determining the longitudes of places?

535. Illustrate the retrograde motion of the superior [planets?

536. How were eclipses formerly beheld?

537. How do you determine the distances of the planets from the earth or sun?

538. Explain the nature of the places of the sun and earth, and show me by a diagram, how you would determine the earth's place in the ecliptic at any time.

539. It is not possible for Mercury to transit the sun, excepting on two days in the year: which are they?

540. What is the sun's apparent diameter in December, and what is it in June?

541. How do navigators prove the earth to be round?

542. What other proof have we that Mercury's orbit is within the orbit of the earth, besides her never being visible in the night?

543. Is the angle any body forms at the eye of a spectator, proportioned to its distance?

544. What means have effectually determined the magnitude of the earth; and by whom were they employed?

545. What particular advantages have resulted from the observations of transits?

546. Why do astronomers consider the sun to be a solid body?

547. What proof can you adduce, that the orbit of the earth is elliptical, and not perfectly circular?

548. How do you account for the sun's rays causing heat in substances?

549. How do mathematicians determine the altitudes of the clouds

550 How is the magnitude of the moon ascertained?

551. What is the reason that comets are not terrible to us, as they were to the ancients?

552. What is meant by the moon's latitude, and how great must her latitude be when near her nodes, not to be eclipsed?

553. Is the sun deprived of his light during an eclipse? If not, how do you account for his appearing so?

554. Explain by a diagram, the nature of the solar and lunar ecliptic limit.

555. How are the days in a northern and southern latitude proportioned with regard to each other?

556. Why is the internal part of the earth considered to be filled with metals?

557. What is the reason that as the sun is nearer to us in winter than it is in the summer, it is colder in the former than in the latter season?

558. How do you explain by a person riding in a coach, the apparent motion of the sun?

559. How do you prove that it is in consequence of the inclination of the axis of the earth, the day and night is unequally divided?

560. By what are the inequalities of the earth's surface occasioned?

561. How high do the vapours ascend, which arise from the earth?

562. Of what is the internal part of the earth composed?

563. How was it that the satellites of Jupiter were first discovered?

564. At a new moon, what kinds of appearances do the earth and sun present to the inhabitants of the moon?

565. Explain the nature of determining the difference of longitude of any two places, by the eclipses of the satellites of Jupiter.

566. How long would sound be travelling from the earth to the nearest fixed star?

567. When the moon appears eclipsed to us, what what body appears eclipsed to the moon?

568. How do modern astronomers distinguish the different stars in the constellations?

569. What proof have we that the darkness which happened at the time of our saviour's crucifixion, was not a solar eclipse?

570. How do you find the distance of any inferior planet from the sun?

571. Explain the nature of a planet's elongation.

572. Illustrate the retrograde motion of an inferior planet?

573. How would you at first sight tell me the name of any planet you observed?

574. What is the exact time the moon's nodes take to revolve around the ecliptic?

575. What advantage did Columbus derive from the superstitions of the West Indians, respecting eclipses?

576. Which is the readiest way to find the name of any particular star we observe in the heavens?

577. How did the Mexicans act during eclipses?

PART III.

PROMISCUOUS EXAMPLES

ON THE

PLANETARY PROBLEMS.

578. If the geocentric place of Jupiter, December 10th, 1822, be $1^s\ 29^\circ\ 26'$, and that of Saturn on the same day $1^s\ 3^\circ\ 48'$, what is the difference in the times of their culminating?

579. December 18th, 1823, does Saturn rise before or after the sun?

580. The difference of longitude of two places is $117^\circ\ 18'$; what is their difference in time?

581. The diurnal arc of Saturn is $173^\circ\ 11'$ on a certain day; how much is it in time?

582. Being at sea, when the sun was on the meridian, I found by a well regulated time-piece, that it was $1^h\ 19'\ 60''$ P. M. at New-York; in what longitude was I?

583. What is the heliocentric longitude of Jupiter, August 4th 1824?

584. Is Venus a morning or evening star August 4th 1825.

585. What is the geocentric longitude of Jupiter, May 4th 1828?

586. On what day will Jupiter enter ♉ in the year 1823?

587. The moon was eclipsed August 3d 1822; the beginning of this eclipse at London was August 2d $10^h\ 52'$ P.M.: what time did it begin at Paris, Madrid, and Petersburg?

588. When the sun's diurnal arc is 200°, at what hour does he rise and set?

589 When it is 3^h A. M. at London, what is the time at Washington?

590. When in the year 1823 will Mars appear on the meridian at midnight?

591. How many days elapse between two conjunctions of Saturn and Venus?

592. On September 11th at London, the sun sets at $5^h\ 32'$; what is the length of his nocturnal arc?

593. If Venus begin to be a morning star, March 10th 1823; when will she next begin to be an evening star?

594. Will Jupiter be a morning or an evening star September 6th 1824?

595. On what day will Saturn next enter ☊?

596. What is the longitude of the earth, June 8th, 1823?

597. How many days elapse between two conjunctions of Jupiter and Venus?

598 How far is the sun distant from the meridian of any place at $11\frac{1}{2}^h$ A. M.?

599. When Mars rises at 6 o'clock A.M. how many hours is he above the horizon?

600. When the sun continues above the horizon $11^h\ 19'$, what hour does he rise and set, and what is the length of his diurnal arc?

601. Does Jupiter rise before or after the sun November 17 1824?

602. Two stars are observed to be on the meridian of a certain place within $2\frac{1}{2}^h$ of each other, what is their difference of longitude?

603. What is the longitude of that place, on the meridian of which the sun appears $2\frac{1}{2}^h$ before he appears on the meridian of London?

604. The geocentric longitude of Jupiter on June 6th 1822, was $1^s\ 20^o\ 29'$, and of the sun $2^s\ 13^o\ 13'$, how long did he rise before the sun, he being a morning star?

605. What is the difference in the longitudes of the Earth and Saturn, April 8th 1825?

606. When will Venus have no heliocentric longitude in the year 1825?

607. What is the geocentric place of Mars, November 6th 1826.

608. When, in the year 1824, will the Earth and Venus have a sextile aspect?

609. Will Venus transit the sun in the year 1823?

610. When will Jupiter next pass his descending node?

611. In what sign of the zodiac will Herschell be, August 19th 1824.

612. If Venus be observed to set $1\frac{1}{2}^h$ after the sun, what is her elongation?

613. What is the sun's place November 6th 1825?

614. When in the year 1825, will Venus and Mars be in conjunction?

615. October 19th 1822, Mars rose at $5^h\ 28'$ A. M. and the sun $6^h\ 48'$; what was their difference of longitude?

616. How many days elapse between two conjunctions of the Earth and Mercury?

617. When, in the year 1823, will Jupiter be on the meridian at midnight?

618. When will Mars and Saturn appear next on the meridian together?

619. Will the earth appear to transit the sun to the inhabitants of Jupiter in the year 1823?

620. What will be the geocentric place of Saturn, May 4th 1823.

621. When will Saturn and Herschell next have a $\triangle$ aspect?

622. When Saturn continues 17^h above the horizon, what is the length of his semi-diurnal arc in degrees?

623. If Jupiter begin to be a morning star May 4th 1822, when will he begin to be a morning star again?

624. How many days from January 1st 1824, before Venus and the Earth will be in conjunction?

625. When next will Saturn and Jupiter appear on the meridian 4 hours after each other?

626. What will be the geocentric place of Venus, July 8th 1823?

627. Will Venus appear to transit the sun in the year 1824?

628. On what day will the next conjunction of Saturn and Herschell be?

629. When, in the year 1824, will Venus and Jupiter be in heliocentric conjunction?

630. What is the longitude of the moon, April 4th, 1824?

631. What is the place of Mercury, as seen from the Sun on July 7th 1825?

632. What will be the longitude of the moon, November 6th 1823, and will she be to the east or to the west of the sun?

Remarks by the American Editor.

The rules for the Planetary Problems, as performed in this work, were not proposed by the author as affording correct solutions. Being founded on the supposition of circular orbits, they will only serve to give general ideas of orbicular motion, the relative motion of the planets, and may afford arithmetical exercises to young learners, that will be useful and agreeable.

The table of the mean diurnal motions of the planets in page 91, will give the longitude of Mercury approximately for a few days only; but will be inadequate to give the position of this planet, or even of Venus, for any considerable time. They may answer for the Earth and Mars, for one or two years without any great error. In about the same proportion, they will give the heliocentric longitudes of Jupiter, Saturn and Herschel, respectively, for a time nearly equal to their periodical revolutions.

As to the Problems on the Globes, they will require the latitudes as well as longitudes of all the celestial bodies, except the sun, to be known. Every teacher of the celestial globe should therefore deduce their geocentric places from the Nautical Almanac. Then the position of the moon or any planet, being represented on the globe with a dot of ink or mark of a pencil, any of the problems relating to them may be as truly performed as those for the sun.

Amongst the great number and variety of questions in this excellent treatise, some of them are several times repeated; but since they may serve to recal the attention of students to some important facts, and impress them more firmly on the memory, they have been permitted to remain as stated by the author. M. N.

PART IV.

PROMISCUOUS QUESTIONS

To be answered by the Globes.

633. What is a vertical circle?

634. How many zones are there?

635. How are the parallels of latitude drawn on the celestial globe?

636. What place is that whose latitude is 48° 23′ N. and longitude 4° 29′ W.?

637. What are the declinations and right ascensions of Castor and Pollux?

638. At Palermo, June 17th, 9h 18′ A.M. what are the sun's azimuth and altitude?

639. What is the right ascension of Saturn, August 17th 1824?

640. In an unknown latitude I observed the altitude of Aldebaran to be 29° 18′, and his azimuth S. 28 E; this was at 9h 16′ P.M. on what day was this, and in what latitude was I?

641. How far distant is Procyon from the northern Pole Star?

642. When it is 9 o'clock A.M. at Lyons, May 8th, where is the sun in the zenith, to what places is it midnight, where is he rising, and where setting?

643. On what day will the inhabitants of North Cape begin to behold the luminary of day after their long and tedious winter night?

644. What are the Antœci of Philadelphia?

645. How is the wooden horizon of an artificial globe generally divided?

646. What are the latitudes and longitudes of Presburgh, Canton, and Aleppo?

647. What is the length of the day at Mecca when the sun rises at 4 19′ at London?

648. How far south of Paris is that place where the sun is vertical on December 11th?

649. What will be the difference in the right ascensions of Saturn and Herschell, May 13th 1825?

650. What are the latitude and longitude of Lyræ?

651. At what hour will the light invigorate the horizon of London, on October 19th?

652. What is the difference of the lengths of the longest day at Buda and Ispahan?

653. What are the azimuth and altitude of Sirius at Novazembla September 6th 8½ P. M.?

654. Will Jupiter be above the horizon of Philadelphia, September 18th 1823, at 9 P.M.?

655. At 7 A.M. at London, April 4th, where is the sun vertical, to what places is he rising, and to what places is he setting?

656. What stars are on the meridian at Madrid when it is $7\frac{1}{2}^h$ P.M. at London, February 8th?

657. On what day is the right ascension of the sun 117°?

658. To what places on the earth is the day of the same length as at Paris?

659. What does the celestial globe represent?

660. To what places on the earth does the sun appear south the same time he does at Moscow?

661. How far is Witehaven north of Guiana?

662. Is the sun ever vertical to the inhabitants of Port Royal; if so, on what days?

663. What is the right ascension of Venus, April 18th 1823?

664. In what manner does the celestial globe represent the apparent motion of the stars, &c.?

665. What part of the earth does the torrid zone comprehend?

666. How many degrees colder is it at Petersburgh than at London?

667. What is the terrestrial globe?

668. What are the rising and setting amplitudes of the sun at Lima, November 4th, and at what hour does he rise and set?

669. In what sign will Mars be when his right ascension is 246°?

670. At what hour does Sirius rise at Bristol, November 4th?

671. What stars are on the meridian of Syracuse at at midnight, November 13th?

672. What is the greatest rising amplitude the sun has at London?

673. On November 25th 1822, the longitude of Venus was 270° 8′; was she a morning or an evening star, and at what hour did she rise and set?

674. How long does constant day continue at North West Cape, Nova Zembla?

675. What place is that whose latitude is 53° 24′ N. and longitude 3° 12′ W.?

676. How far distant is Jerusalem from Naples?

677. How far east of Cork is Paris?

678. What is the brazen meridian of the terrestrial globe?

679. If an eclipse of the moon begin at 7h 19′ 24″ at London, what time will it commence at Falmouth?

680. How are the constellations represented on the celestial globe?

681. What is the longitude of a celestial body?

682. What are the poles of the horizon?

683. On June 26th, 11½h P.M. 1824, the moon will be eclipsed; where on the earth will it be visible?

684. Will the Sun or Mars have the greater right ascension November 7th 1823.?

685. How is the zodiac represented on the celestial globe?

686. At North West Cape, when does constant day begin, and how long does it continue?

687. Will Jupiter be a morning or an evening star September 19th 1825?

688. I oberved the Pleiades to culminate at 9h 16′ when their altitude was 47° 19′; what were the latitude and day of the month?

689. What part of the earth does the north temperate zone include?

THE END.